Environment Canada Environnement Canada

BIOLOGY IN THE NEW REGULATORY FRAMEWORK FOR AQUATIC PROTECTION

PROCEEDINGS OF THE ALLISTON WORKSHOP

NATIONAL WATER RESEARCH INSTITUTE

ENVIRONMENTAL
PROTECTION

BIOLOGY IN THE NEW REGULATORY FRAMEWORK FOR AQUATIC PROTECTION

Proceedings of the Alliston Workshop
held April 26–28, 1988

Edited by

K.E. Day and E.D. Ongley
National Water Research Institute

R.P. Scroggins and H.R. Eisenhauer
Environmental Protection

92-00307/

TABLE OF CONTENTS

Alliston Workshop Proceedings

EXECUTIVE SUMMARY 1

1. *Introduction* 3

2. *Synthesis of Background Papers* 3

3. *Synthesis of Working Group Discussions* 10

4. *Appendices*

Appendix A
Alliston Workshop Program 15

Appendix B
Extended Abstracts of Presentations 16

Appendix C
Rapporteur Reports of Working Groups 61

Appendix D
List of Participants 70

Appendix E
Organizing Committee 71

ACKNOWLEDGEMENTS

This national workshop was hosted and sponsored by the National Water Research Institute and Environmental Protection, Conservation and Protection, Environment Canada. Financial assistance from the Ontario Ministry of the Environment is gratefully acknowledged.

The Workshop Organizing Committee would like to thank all speakers for providing an informative baseline from which all discussions could progress. In addition, all participants are thanked for both their questions to the speakers and their input into the conclusions and recommendations put forth by the working groups. The chairpersons K.R. Solomon, K. Marshall, P. Blackall and B. Baker provided guidance to the working groups and their efforts in this regard are acknowledged. Thanks to the rapporteurs, D. Carlisle, P. Stokes, H. Eisenhauer and K. Day for their reports. A special thanks to Johanne Legault for all her work in coordinating the finer details of the workshop.

Copies of this report are available from:

National Water Research Institute
P.O. Box 5050
867 Lakeshore Rd.
Burlington, Ontario L7R 4A6
Atten: K.E. Day or E.D. Ongley

or

Environment Canada
Ottawa, Ontario, Canada
K1A 0H3
Atten: R.P. Scroggins

EXECUTIVE SUMMARY

Recent legislative initiatives in Canada such as the Canadian Environmental Protection Act (CEPA) and the Ontario MISA program, provide the policy framework for expanding the use of biological criteria to achieve aquatic environmental protection. This has significant implications for those government agencies which establish regulatory criteria, for those industries which will be subject to new forms of regulatory criteria, for private consultants and laboratory companies that will do much of the biological testing and evaluation, and for research organizations both in government and in the university sector.

The benefits of incorporating biological standards both into end-of-pipe criteria and for ambient effects assessment, are widely recognized. There are, however, differences of opinion about the nature of testing protocols, about the practicality of biological tests, and about the level of scientific knowledge and practical expertise available to formulate and implement such regulations at this time. There are concerns that government may not be truly committed to biological assessment and may not be willing to invest sufficiently in R&D to achieve appropriate measures of biological integrity in receiving waters. Requirements for biological assessment in Canada have potentially significant benefits for the Canadian consulting and laboratory testing industry, especially from the perspective of fostering a healthy service industry with enhanced capability for exporting services. There are, however, concerns about lack of uniform quality assurance procedures within the industry and about how governments will implement testing requirements.

The Alliston Workshop provided a forum for discussion of these and other issues related to the use of biology for aquatic protection. Formal presentations by representatives of all stakeholder groups are contained in the body of this report. These include summaries of current regulatory legislation that invoke biological testing criteria (CEPA, MISA, PCP Act), reviews of biological testing science and its applications in federal and provincial programs, views of selected regulated industry groups (petroleum refining, steel manufacturing and pesticide chemicals) and, lastly, perspectives of the environmental services sector (consultants and biotesting service industry).

Four concurrent working groups addressed specific questions and developed recommendations which form part of this executive summary. Additionally, during formal presentations and ensuing discussion, important points of view emerged which represent issues of sensitivity, especially to non-government stakeholders. These are included in the executive summary as "Major Messages" and should be carefully considered by government officials in the course of developing regulations and ensuring dialogue with the private sector.

The Alliston Workshop was organized by Conservation and Protection as part of its ongoing policy dialogue with stakeholders during CEPA implementation. Attendance was by invitation to ensure a balanced representation across Canada.

RECOMMENDATIONS

The principal recommendations were derived from discussion of specific questions by members of four independent working groups.

QUESTION 1. *What are the benefits and limitations of biological testing/monitoring strategies as compared to other possible methods and strategies (e.g., the chemical-specific approach)?*

1. It was recommended that the Federal government develop a national framework for biological toxicity tests and make the policy decisions required to set biology-based regulatory standards in place. In addition, the Federal government should expedite the development of standardized protocols for biological toxicity tests.

2. Biological testing and monitoring must be integrated with chemistry in a multi-disciplinary manner when applied in hazard assessment and regulatory control.

3. Sublethal and chronic tests need to be developed to provide more sensitive monitoring tools for detecting toxic effects in ambient waters.

4. Mechanisms for improved communication, awareness and understanding of the applied uses of biological tox-

icity tests amongst the scientific community, regulatory agencies, industry and the public sector must be pursued.

QUESTION 2. What should be the role of government laboratories in biological testing/ monitoring R&D?

5. The Federal government must maintain a strong research and development capability and continue to transfer technology developed in the field of biological testing and monitoring to the private sector.

QUESTION 3. Should government have a quality assurance/ quality control (QA/QC) role in regulatory programs where biological testing/monitoring is a component?

6. The Federal government should provide guidance and show leadership in the area of biological testing and monitoring (QA/QC), e.g., policies, guidelines, laboratory accreditation, toxicologist certification, etc.

QUESTION 4. What role should government play in ambient effects assessment?

7. Government should be responsible for the maintenance of long–term ambient monitoring schemes while industry should be responsible for the assessment of immediate areas of impact, e.g., end–of–pipe and mixing zone, with occasional auditing by the government.

Important additional recommendations, explanations and comments are provided in the body of this report.

MAJOR MESSAGES

The purpose of this Workshop was to provide a forum for discussion of points of view by the various stakeholders. The following messages arose consistently from formal presentations and during informal discussions.

1. Industry views biological assessment as a useful supplementary activity but argues that chemical tools are more practical than biological tools for process control of wastewater facilities.

2. Industry is concerned that standardized tests are inappropriate for compliance regulations but feels that they will be adopted by government for ease of implementation. Tests should be tailored to specific receiving waters.

3. Government views standardized acute toxicity tests as a reasonable regulatory compliance tool for generic first–level environmental protection, but feels that chronic toxicity tests should be required on a site–specific basis as warranted.

4. Industry feels that aquatic regulations should be factored into the total cost for protecting air, soil and water.

5. Historically, government regulations for the three environmental media have not been developed using an holistic approach.

6. Industry generally perceives that there are mixed and overlapping federal and provincial agendas.

7. Government extols the virtue of dialogue in the regulatory agenda.

8. Industry is sceptical that dialogue has much impact on regulators.

9. The consulting sector finds it easier to work in the United States than in Canada, and they perceive that there are implicit interprovincial restrictions within Canada.

10. The consulting industry wants clear directions from government on the testing protocols to be used.

11. Consultants are concerned that government will encourage the private sector to gear–up for biotesting for regulatory purposes but not follow through with specific requirements for biotesting in regulations. Should this situation develop, consultants will be forced to limit their development in this field or seek business opportunities in the United States where there is demand for biotesting.

12. The consulting industry is concerned that government will not honour its commitment to the concept of biological integrity as the measure of success of regulations; rather, government will revert to its traditional engineering approach using R&D funds for pollution abatement technology development without adequate R&D on biological assessment.

13. There is a concern on the part of the consulting industry that universities are training academic researchers rather than professionals useful to the consulting industry.

INTRODUCTION

Recent legislative initiatives in Canada, such as the Canadian Environmental Protection Act (CEPA) and the Ontario MISA program, provide the policy framework for expanding the use of biological criteria for achieving aquatic environmental protection. This has significant implications for those government agencies which establish regulatory criteria, for those industries which will be subject to new forms of regulatory criteria, for private consultants and laboratory companies that will do much of the biological testing and evaluation, and for research organizations both in government and in the university sector.

The benefits of incorporating biological standards both into end–of–pipe criteria and for ambient effects assessment, are widely recognized. There are, however, differences in opinion about the nature of testing protocols, about the practicality of biological protocols,and of the level of scientific knowledge and practical expertise available to formulate and implement such regulations at this time. While government views biological testing of effluents as a cost–effective method of achieving environmental objectives, industry has reservations about such tests for process control of waste treatment plants.

The consulting and laboratory service industry has a significant role to play in implementing any biotesting or assessment program. Questions remain, however, over the precise nature of prescribed tests, the level of participation of the private sector and, indeed, whether or not government is truly committed to biological assessment and is prepared to invest in the R&D to achieve appropriate measures of biological integrity in receiving waters. Quality assurance and laboratory certification in the biotesting industry must be considered as part of any regulatory agenda; however, the role of government has not been defined. Expansion of biotesting requirements in Canada has the potential for creating additional expertise which can augment the competitive position of the Canadian environmental industries sector.

A significant research capacity exists within government to meet its own requirements. The relationship between government laboratories and the private sector must be defined so that activities are complementary and government research is supportive of the private sector and expands its competitive position. Because of increasing demand both for knowledge in this field and for trained expertise, the university sector has also an important role to play.

The Alliston Workshop was created to provide a forum for discussion amongst regulators, regulated industry groups, environmental consultants and the laboratory services sector, and government and university researchers. The intent of this Workshop was to discuss issues of broad policy significance so to ensure that governments have the benefit of advice during the development of regulatory criteria and to ensure that other government activities, such as research and development, is carried out in a manner which is consistent with and supportive of the broadest possible constituency. It was not the intention of this Workshop to discuss or debate the details of specific test procedures.

Participation in the Workshop was by invitation in order to limit the size to manageable proportions, and to ensure national representation by the various stakeholders. This format included formal presentations to provide necessary background information, and four concurrent working groups which addressed specific issues and formulated a concensus for presentation to the full Workshop. This Proceedings volume contains a synthesis of the formal presentations and of the recommendations of the four working groups. The full (extended) abstracts of the formal presentations are contained in the Appendices.

SYNTHESIS OF BACKGROUND PAPERS

The following synthesis attempts to capture the essential points and arguments of the various speakers. In some cases speakers speak for an entire constituency; in other circumstances, speakers present more individualistic views and opinions. Not all presentations are summarized as separate entities; in some cases several presentations have been amalgamated for ease of synthesis. Readers are referred to the individual papers for presentors' complete views.

LEGISLATIVE AND REGULATORY FRAMEWORK

Canadian Environmental Protection Act (CEPA)

CEPA is a consolidation of some of the major existing environmental protection authorities of the Minister of Environment (federal) and a charting of new directions for federal environmental law. It consolidates the Environmental Contaminants Act, Clean air Act, Ocean Dumping Control Act, Part III of the Canada Water Act, and Section 6(2) of the Department of the Environment Act. Not included are the: Pest Control Products Act, Transport of Dangerous Goods Act, or Section 33 of the Fisheries Act.

"Environment" in this Act is defined as encompassing air, land, water, all layers of the atmosphere, and all organic and inorganic matter and living organisms. The Act embodies an ecosystem approach to environmental protection. The Act adopts a "life-cycle" (i.e., cradle-to-grave) approach to toxic chemical management so that all aspects of chemical production, use, and disposal are controlled. The Act requires the formulation of environmental quality objectives, guidelines and codes of practice; it regulates federal activities and undertakings; it imposes penalty provisions which are more in line with real costs of environmental pollution.

For reasons of toxicity, persistence and use, fifty chemical substances will be identified by an expert panel for evaluation and potential registration. As part of the evaluation, Canada has joined the cooperative OECD program wherein participating countries share evaluation data. Under the Act, new substances must be assessed prior to introduction into Canada. Typically, data will include physical and chemical properties, information on toxicology, bioaccumulation and persistence, and susceptibility to chemical changes and interactions within the environment.

Within the 149 sections of CEPA there are 27 major and directly pertinent roles for biologists. However, bearing in mind that the decision-makers are unlikely to be biologists, it is incumbent upon biologists to:

- take the initiative to bring relevant information to the attention of decision-makers
- plan ahead so as to be prepared to influence decisions
- identify the most appropriate points of intervention within the decision-making process
- ensure that interventions are focussed and succinct, and that recommendations are practical and constructive

The Ontario MISA Program

The MISA (Municipal-Industrial Strategy for Abatement) Program is part of a larger set of regulatory tools for environmental protection in Ontario. These tools include:

Certificates of Approval: required by every discharger. Certificates may specify loading limits based upon biological criteria.

Control Order: specifies actions that must be taken by the discharger. In most cases the problem is one of biological impacts such as fish kills.

Litigation: includes prosecutions for violations or non-compliance, and appeals against Certificates of Approval or Control Orders. Litigation is based upon "potential to pollute" and degree of impact as determined by biological criteria.

MISA: is a regulatory program that will control and reduce the amount and concentration of toxic contaminants in all municipal and industrial effluents discharged to surface waters. The long-term goal is the elimination of toxic substances in Ontario waterways. The MISA program follows two tracks — effluent regulations and water quality studies.

Using chemical and biological methods, each major industrial sector and municipal sectors will be required to identify and measure contaminants in their effluents. Effluent criteria will be achieved using Best Available Technology Economically Achievable (BATEA). Consultation with industry, essential in the MISA program, is achieved through a series of Joint Technical Committees.

Water quality studies, involving biological impacts assessments, are intended to assess the efficacy of the regulations and to trigger policy revisions. Delays in the development of sector-specific BAT(EA) regulations have delayed the water-quality component of MISA by approximately three years. This is due, in part, to several scientific and perceptional problems inherent in biological criteria. Firstly, water quality standards are perceived to be uncertain and require experimentation and verification. Secondy, it is perceived that water quality studies might delay delivery of BAT(EA) sector regulations. Thirdly, biological criteria are not universally accepted by industry as meaningful and transferable related to production of effluent standards.

Biological components of the regulations, although seen as being very costly, are probably less expensive than blanket chemical coverage. However, there is considerable debate over how to articulate site-specific biological tests into effluent limits. There are other significant questions such as the capability of government and the private sector's testing capabilities, QA/QC considerations, laboratory certification, etc..

In the interim, water quality studies using biological assessment tools are being carried out at six pilot locations.

The objective is to develop water quality evaluation procedures which can be used by industry to examine the efficacy of technology-based effluent limits. It is expected that full implementation of water quality-based effluent limits will be phased in in about five years.

Pest Control Products Act

Pesticides are regulated in Canada under the Pest Control Products Act and Regulations. Final authority for this Act lies with Agriculture Canada; however, registration is essentially consultative in nature. Assessments of various types of risk are provided by:

– human risk: food, exposure – Health & Welfare Canada

– physical/biological environment – Environment Canada

– fish and fish habitat – Fisheries and Oceans, Canada

The essential principle of the Act requires a presale assessment to ensure safety, merit, and value before use. These assessments are based upon scientific criteria and are reviewed by experts for risk/benefit considerations in the decision–making process, and then communicated to stakeholders. Most pesticides pass through four regulatory phases: research permit for field release, temporary registration, full registration, and re–evaluation.

Data Requirements: Currently, registration information includes chemical, toxicological, environmental (fate and environmental toxicology), and performance data. Ten percent of the studies must be performed in Canada; the remaining studies, mostly toxicological, are available from and used by other countries. Canadian studies must provide data which are specific to Canadian agronomic, geographic and climatic conditions. These are mainly performance, residue and environmental studies.

Risk–Benefit Assessment: Unlike American legislation, the PCP Act is silent on the process of risk – benefit assessment. In practice, risk – benefit assessment has been an integral component of regulatory decision–making. Political and socio–economic factors may also enter into consideration. The assessments are written and published by advising departments for discussion and consultation amongst advisors, industry and other experts.

Re–evaluation: In 1984, the 500 pesticides registered under the PCP Act were ranked into five categories based upon the quality of the supporting data. Ten percent were fully acceptable, forty–five percent were fair, twenty–five percent poor to critical, and 20 percent unacceptable. It is likely to take 15 years to complete these re–evaluations.

Challenges: Current challenges lie in developing guidelines to regulate the products and processes of biotechnology, microbial and biopest control agents, to identify aquatic toxicology testing requirements and to reduce potential pesticide contamination of groundwater.

BIOLOGY IN THE REGULATORY FRAMEWORK

Biology and CEPA

CEPA and its regulations contain both mandatory requirements and discretionary opportunities for biological testing and assessment. These flow from the ecosystem perspective of the Act.

Routine Environmental Quality Monitoring: Biological tools can be used to determine the quality and long–term health of the aquatic environment. They can equally be used as screening mechanisms to flag current or potential problems.

Research on Environmental Pollution/Contamination: A broad variety of biological tools have relevance in assessing toxicological implications, remediation requirements, and nature and extent of impact areas.

Control Technologies: Biological assessment contributes to identification of toxicity of in–plant sources and of effluents and leachates. It also is used to demonstrate efficacy of treatment technologies for toxicity reduction.

Formulate Environmental Quality Objectives: Biological criteria of a narrative and/or numerical character should have a major role in determining desirable levels of environmental quality. Pollution control strategies, such as planned in MISA, would be judged in terms of chemical and biological criteria.

Characterization of Chemical Substances: The role of biology is threefold:

(a) Biological criteria for determining potential concerns as a basis for setting priorities for further action.

(b) Assess environmental hazard of named substances.

(c) Development and evaluation of control and clean–up technology.

New Substances: With the exception of biotechnology products or polymers, there are mandatory biological data for new chemical substances. These include: fish and Daphnia acute toxicity, mutagenicity, biodegradation and bioaccumulation, acute mammalian toxicity, skin irritation/sensitization, and repeated dose toxicity. Biotechnology products have further biological requirements.

Toxic Substance Regulations: Regulations can include a broad spectrum of requirements. Although not explicit in the Act, it is likely that biological requirements are likely to be included. This might include specific measures of toxicity in effluents and leachates.

Ocean Dumping: Biological testing is well established in ocean dumping criteria.

Adequacy: Biology plays an essential role in the evaluation of the effectiveness of control measures and remedial actions for environmental protection. Provisions for such activity are found in the obligatory review cycle built into CEPA, and indirectly in various other places in the Act.

Challenge: The degree of use of biology within CEPA will depend upon the demonstration of practical and effective biological approaches. Further, it will depend upon the degree of success by biologists in convincing "regulators" and stakeholders that biology can be used in a cost-effective and pragmatic manner.

Biology and MISA

Toxicity testing is a basic component of the new monitoring regulations under development within MISA. While it is not yet known the extent to which biologically-based limits will be incorporated into compliance legislation, it is reasonable to assume they will be important. Clearly, it is illogical to attempt to eliminate toxic substances from effluents without first assessing whole effluents for toxic effects.

Ontario has long used acute lethality to fish as a measure of impact of industrial discharges in the province. More recently, acute lethality to Daphnia magna has been used. Although biased due to differing sampling requirements, these data provide an overview of quality of discharge across the province. The number of discharges exhibiting lethality suggest that removal of sublethal effects may be unrealistic. However, data suggest that removal of acute lethality may, in most situations, also control most sublethal effects. It is, however, difficult to determine the degree of bioaccumulation in organisms found in receiving waters using only acute toxicity tests on effluents. Ontario has used a variety of measures of bioaccumulation, such as tissue concentrations in forage fish, tissue analysis of sport fish and caged organisms, to determine potential for bioaccumulation and impacts of point sources.

Biological vs. Chemical Monitoring: While it is essential that effluents be characterized for selected key chemical substances, complete chemical characterization is not only extremely expensive, but the ability to interpret environmental effects of hundreds of chemicals is extremely limited or impossible. Biological testing provides a cost-effective means of measuring the aggregate effect of total chemical content of the sample. Similarly, for water quality objectives, guidelines and criteria, toxicological data for the range of compounds that may be present is usually incomplete. Biological monitoring permits an assessment of the cumulative chemical impact on the aquatic system.

Biological Data: Anticipating the need to handle large amounts of toxicity and biological data, the Ontario Ministry of Environment has developed a data management program called TOXDATA.

Biology and the Pest Control Products Act

The use of biological data under the PCP Act or indeed for any other regulatory mechanism which focusses on control of specific substances or products, is guided by three principles.

1. Endpoint: The data must focus on the chemical under investigation. Data submitted on other substances is unlikely to be used by regulators.

2. The 80/20 Rule: One cannot know all there is to know about a chemical. Regulators must exercise judgement when determining "need to know" versus "nice to know" data.

3. Proponent Pays Principle: Under the PCP Act the proponent is responsible for all information required in the pre-registration evaluation of a new pesticide.

Responsibility of Government

1. Clearly define the information required.

2. Assure that information requested is indeed what is needed.

3. Develop protocols which permit the proponent to obtain the necessary data.

4. Audit the data base to ensure its integrity.

Responsibility of Proponent

1. Show that concerns raised by regulators are unwarranted.

2. Demonstrate that hazard can be alleviated by specific use-practices.

3. Show that benefits of use outweigh the risks.

Biology: Government scientists should be involved in the development of bioevaluation techniques. It is important to be able to answer the "so what" question. Cost-effective biological screening techniques are needed at the initial evaluation step for identifying and priorizing environmental effects that might be caused by pesticide use. It is recognized that chemical identification in the field cannot be equated to an environmental effect. Biologists should be giving thought to screening techniques such as surrogate systems, mathematical models, use of indicator species and metabolic indicators of stress.

SCIENCE OF BIOLOGICAL EFFECTS ASSESSMENT

Definitions

Ecotoxicology was defined by Butler (1978) as the toxic effects of physical and chemical agents on living organisms and especially on populations and communities within defined ecosystems. The objective of applied ecotoxicologists is to develop a workable protocol to enable early and cost-effective prediction of hazard at an acceptable level of uncertainty to guide regulatory and industrial decision-making.

Toxicity Tests are standardized biological testing procedures which measure the responses of aquatic organisms exposed to samples of wastewater, leachate or ambient water. Test response can be either rapid (acute) or longer-term (chronic). The end-point of acute tests is usually lethality but may include sublethality. Tests for chronic effects may include inhibition, mutagenesis, etc.

Biomonitoring is the use of biota to measure residues of contaminants in the tissue of either indigenous or introduced organisms in ambient waters in order to detect the presence of low levels of contaminants in the environment and to determine bioaccumulation.

Bioeffects Monitoring is the study of direct or indirect effects of contaminants in receiving waters on species, populations or communities on a spatial or temporal basis.

Canadian and International Biological Effects Assessment Activities

Biological techniques have been used informally as investigative tools in Canada since the 1940's, and Canada has played a significant role in the development of these techniques both nationally and internationally. In the last two decades, biological testing or ecotoxicological procedures have been formally incorporated into some pollution control strategies in Canada (e.g., the Fisheries Act) and there is every expectation that this will continue in the new climate of CEPA, MISA and other initiatives. Biological procedures, including toxicity tests, are being actively built into current policies, frameworks, strategies, guidelines and regulations in a number of countries in all continents. Examples include: the effluent testing framework of West Germany; the US EPA Clean Water Act; NEPDF program where both freshwater and marine acute and chronic tests are being employed for site-specific regulation of wastewater; and the OECD toxic chemical protocols for toxicity testing.

Biological and Chemical Evaluation

Combining biology with chemical analysis is an effective analytical strategy for impact assessment and regulatory advice.

Chemical approaches are appropriate for quantification of individual substances and modelling individual chemical pathways and fate. Chemical approaches also conform with the traditional design and operating procedures of wastewater treatment systems.

Biological approaches: (1) measure toxic effect of the entire sample, (2) are cost-effective for toxicity assessment, (3) quantify synergistic and antagonistic effects common to complex mixtures, (4) directly quantify biomagnification and genotoxic potential, (5) can measure the impact of the effluent on the receiving environment in time and space.

Cost-Benefit and efficacy of combined chemical and biological assessment can be demonstrated from many studies.

There is a need for more practical, reliable and predictive techniques for biological assessment of water pollution and water quality. It is also important to understand the level of protection that a biological or ecotoxicological test offers to an ecosystem.

PRIVATE SECTOR PERSPECTIVES ON USE OF BIOLOGY IN REGULATION

The following views were solicited as representative of major industry groups.

Regulated Industries: Petroleum Refining

Industrial Response to Changing Need

Shell Canada, as an example, has now closed its Oakville plant even though it was built in 1962 as a state-of-the-art facility. In 1985, Shell opened its Scotford refinery, near Edmonton; in addition to in-plant abatement measures this state-of-the-art plant produces almost no effluent in comparison with older plants. Biological treatment and assessment are routinely used in the industry.

Tiered Assessment

The only parameters that can be measured routinely, with reliability and which are capable of interpretation are: mortality, reproduction and growth. Because chronic studies on multispecies are difficult, single species are used to establish concentration-effect relationships.

Tier 1: screening for effluents with a dilution factor < 10,000, an acute margin of safety of 1,000, and a 14 day–Daphnia chronic margin of safety of 100.

Tier 2: estimate of the variability of plant operations, species sensitivity, and chronic toxicity.

Tier 3: confirmation of work on site with actual conditions.

Tier 4: field studies upstream and downstream using ecological parameters.

Need for Policy on Water Discharges

The current emphasis upon enforcement procedures rather than on abatement linked to socially beneficial ecological management, is deplorable. Rather than focussing on testing criteria per se, Canada should carry out socio-economic studies of receiving waters as part of a larger environmental concern (air, soil, etc.) and develop specific effluent criteria and enforcement standards based upon intended use of receiving waters. Regulations which focus only upon aquatic impacts ignore costs which are transferred to other environmental compartments such as air and land (e.g., waste storage). Industry has a major problem with the failure to adequately communicate the concept of risk to the public.

Federal Government Role

1. Water quality standards and criteria. 2. Effluent characterization, test methods and procedures.

3. Watershed quality standards, evaluation procedures and monitoring.

4. Assessment of socio-economic benefits relative to water usage.

Regulated Industries: Steel

Biomonitoring is a complex evaluation process for which evaluation techniques are evolving. As an example in the steel industry, a bioevaluation program for a single integrated plant took six years and cost $300,000. The results demonstrated that the effluent was non–toxic to fish and that indigenous organisms were not stressed.

Biomonitoring – Pros and Cons: Produces visible demonstration of efficacy of control measures and removes the mystery of water chemistry data. Biomonitoring plays a useful supplementary role in specific circumstances and for specific reasons and can serve as a warning device for detecting deterioration in water quality. Biomonitoring should be used as a screening device to provide information for developing programs for chemical testing of effluents. It is not a practical operating tool for controlling water treatment facilities. Biomonitoring is site–specific; difficulties are created if biomonitoring is required as a general regulatory initiative. Biomonitoring is expensive.

Role of Government: Government, in cooperation with industry, should:

- develop standards, protocols, etc. for biological testing
- develop codes of practice.

Regulated Industries: Pesticides

Pesticide use, unlike other regulated industries, is a non-point source issue. This and other regulated industries object to the synonymous use of "industry" and "polluter"; this denies the significant advances made in recent years in acceptance of environmental responsibilities by the chemical industry.

New Areas of Study for Crop Protection Chemicals

At present there are no detailed guidelines for (aquatic) environmental toxicology studies comparable to guidelines for terrestrial fate. Approaches might include extension of acute studies to other species in the aquatic food chain thought to be under environmental pressure or which have particular sensitivities. Sub–lethal effects, including behavioural and pathological parameters, may be more sensitive measures of toxic effects and exposure.

How New Studies Should be Brought into the Regulatory Framework

It is reasonable that the industry should be directly involved in development of bioassessment techniques relating to their products; it is unreasonable that the industry be required, as part of the regulatory framework, to undertake fundamental research unrelated to their products. Large–scale studies of pesticide impacts, such as that being conducted by Environment Canada in the Yamaska River basin, are useful post–registration studies but are inappropriate for registration purposes due to interpretive difficulties associated with multiple contaminants.

New studies required by regulators should be clearly defined in terms of assessment criteria and study design. Environmental biology requirements should be incorporated into trade memorandum T–1–255 which deals with laboratory and field studies of degradation and persistence. Aquatic studies should not be divorced from studies of soil or groundwater. Integrated studies would promote commercial contract sources in Canada for studies having primary applicability in Canada. Test facilities must be available prior to introduction of environmental biology requirements. Test requirements should recognise that the majority of crop pesticides are designed for field crops in the prairie provinces.

Economic Implications of New Study Requirements

- Sales in the crop protection chemical market have declined over the past three years. Declining profitability mitigates against new test requirements.
- Absence of a phased registration system in Canada is a handicap; in other countries, initial registration for limited use permits assessment of longer–term risks in conjunction with commercial use conditions.
- Current costs of meeting registration requirements are already excluding the introduction of new products in limited market areas; this is especially so for Eastern provinces and British Columbia. This has direct impact on competitiveness of food producers.

Laboratory Service and Consulting Industry

Ecosystem Analysis as a Biomonitoring Tool

Because laboratory testing procedures are not good surrogates of ecological response, it is necessary to carry out field investigations to determine compliance to criteria based upon protection of the biological community. Biological/ecological evaluation criteria commonly include species presence or abundance, biological community analysis and pathogenic effects.

Regulatory criteria commonly fall into two broad categories: (1) public health (chemical and biological criteria), and (2) ecosystem impacts (physical, chemical and biological criteria). Criteria for public health purposes are usually expressed in numerical values. Ecosystem impacts are difficult to express numerically because of the complexity of the information obtained and the complexity of the response being characterized. Progress is being made in developing numerical indices of complex response; an example is the Index of Biotic Integrity (IBI) used in the Great Lakes.

Role of Environmental Consulting Industry

- provide impartial professional services to government and industry clients.
- are directly involved in technical confrontations between regulatory and industry objectives.
- because of direct involvement in issues and problems are best positioned to apply new technologies.
- provide economic opportunities for the Canadian economy.

Lessons from Earlier Aquatic Toxicity Programs

- Lack of purpose and direction
- Program confusion
- Regulatory confusion
- Testing methodology poorly defined
- Terminology
- Federal and provin cial program overlap

There is confusion in the industry about overlapping federal and provincial requirements; there is uncertainty over test protocols and reliability criteria. Government should play a strong role in developing appropriate QA/QC practices together with enforcement of standards in laboratory practice. If effluent regulations are in support of ecological criteria, government must ensure that environmental biology is given support equal to that traditionally given to engineers for pollution control technology. With the trend towards biological assessment, new data base management systems must be developed to deal with this new type of data.

Opportunities

The new regulatory framework, together with similar directions in other countries, provides for significant opportunities for those companies which bring appropriate products and services to the marketplace. R&D in biological assessment methodologies is essential if Canada is to take advantage of these developments. The private sector can make a significant contribution to R&D and is well positioned to export services. The opportunity would be enhanced if constraints to free trade within Canada, imposed explicitly and implicitly by federal and provincial government practices, were eliminated.

SYNTHESIS OF WORKING GROUPS

Four working groups were assembled from the list of participants at the workshop. Each group included representatives from the federal and provincial governments (i.e., regulators, scientists and managers), industry, environmental consultants and academia. Thus a broad range of viewpoints were represented in each of the working groups. Working independently under the direction of a chairperson, the members of each working group were asked to address four questions as follows:

1. What are the benefits and limitations of biological testing/monitoring strategies as compared to other possible methods and strategies (e.g., the chemical-specific approach)?

2. What should be the role of government laboratories in biological testing and monitoring research and development?

3. Should government have a quality assurance/quality control (QA/QC) role in regulatory programs where biological testing and/or monitoring is a component?

4. What role should government play in ambient bio-effects assessment?

A diverse list of identified needs, differing viewpoints and conclusions from each working group is summarized in each rapporteur's report (Appendix C). In general, input by all participants, especially from industry and consultants was frank and positive.

The summary notes of each rapporteur's report were reviewed by the workshop organizational committee. Major points of discussion and/or conclusions common to all four working groups are outlined below. Points and conclusions which were not common to all working groups are also discussed briefly and presented in Table 1.

The responses to the four questions are as follows:

Question #1. What are the benefits and limitations of biological testing/monitoring strategies as compared to other possible methods and strategies (i.e., chemical-specific approach)?

In order to facilitate discussion on this question, each working group was provided with a list of general classes of biological testing and monitoring techniques and a working matrix to focus direction on identified needs, potential benefits/limitations, existing methods/strategies, adequacy of existing methods/strategies, and R&D requirements for each technique. All four groups experienced difficulties in completing these matrices as outlined, and therefore opted to discuss the needs for biological toxicity tests in a broader context and specifically as they relate to the regulatory framework. The generic needs and recommendations identified by all four working groups are summarized below. Each recommendation is followed by explanatory notes and pertinent points raised in discussions.

1. It was recommended that the Federal government develop the framework for biological toxicity tests and provide the policy statements required to set biology-based regulatory standards in place. In addition, they should also develop standardized protocols for biological toxicity tests.

It is the responsibility of the government to set clear and precise requirements regarding the use of biological toxicity tests for regulations, guidelines, hazard assessment, etc. Standard protocols should be formalized by governments for those tests that are already well-proven. These protocols should be incorporated into appropriate new and amended regulations or guidelines as soon as possible. Research and development should be concentrated on promising tests that are not yet proven and as newer, more sensitive, cost-effective and efficient tests mature, government should provide standard protocols for these tests.

Concern was expressed by industry that different jurisdictions may demand different biological testing methods or procedures for regulation within a region. Although it was recognized that some biological toxicity tests may be site-specific or industry-specific, it was recommended that protocols be standardized or harmonized as much as possible on a national basis and that they be related to other protocols required internationally.

2. Biological testing and monitoring must be integrated with chemistry in a multi-disciplinary manner when applied in hazard assessment and regulatory control.

A clear need was expressed for both laboratory and field biological toxicity tests to be used in conjunction with chemistry for regulatory purposes. For hazard assessment, the ideal protocol would consist of tiers of tests, with a "battery of tests" at each tier containing tests with quantified triggers leading to the next tier, if and only if, the trigger is tripped. Initial screening would be by simpler tests, i.e., short-term acute and chronic toxicity tests, followed by longer-term chronic and sublethal toxicity tests. More comprehensive ecotoxicological tests involving several trophic levels could be incorporated in the final tiers to assess ecosystem dysfunction. The tiered approach provides for the most effective use of funds and other resources but the selection of the tests at each tier requires a great deal of skill. At present, there are a limited number of toxicity tests available which provide sufficient sensitivity to detect sublethal ecosystem effect. In addition, field validation of such toxicity tests is rare but essential if these tests are to be considered to truly protect whole ecosystems.

3. Sublethal and chronic tests need to be developed to provide more sensitive monitoring tools for detecting toxic effects in ambient waters.

The detection of effects of contaminants on individual species, populations and communities in ambient waters will, to a large extent, require different techniques than those used in effluent monitoring. There are some biological effluent monitoring tests currently available which are sensitive enough to detect "near–field effects", e.g., in the mixing zone, of discharges in ambient waters. Generally speaking, however, high sensitivity sublethal and chronic monitoring techniques required for measuring far–afield effects are still in the early stages of development. For the most part, ambient testing involves separate philosophical implications because the cause/effect/solution relationships are seen to interact through a number of linkages. For example, if biological toxicity tests are conducted on an ambient water sample and the results indicate toxicity, it may be difficult to identify a specific effluent discharge if there is more than one source of wastewater being discharged in the vicinity. In addition, synergism, additivity and/or antagonism may be occurring in mixtures of contaminants.

Tests of ambient water quality should be tied to water quality objectives. At present there are some water quality objectives for ambient waters, e.g., in the Great Lakes, but these objectives are chemical–specific only. There is a need for biological criteria or objectives for ambient waters.

All four working groups strongly recommended that chronic and/or sublethal biological toxicity tests are essential when attempting to detect toxicity in ambient waters.

Several groups suggested that more flexible, site–specific biological testing and monitoring procedures may be required for ambient water impact assessment.

4. Mechanisms for improved communication, awareness and understanding of the applied use of biological toxicity tests amongst the scientific community, regulatory agencies, industry and the public sector must be pursued.

Concern was expressed that neither government nor industry are trusted by the public in matters of environmental protection. Therefore, there should be an improved means of education and/or explanation of the significances and purposes of biological toxicity tests and their results. Such education would assist the public in their understanding of regulations and to assure the public that reasonable measures are being taken to protect the environment and reduce risks.

There is a need to clarify nomenclature and/or definitions in order to have consistency amongst users and interpretors. This results from a confusion over the fact that some terms which are common in name have different meanings to human and environmental toxicologists, e.g., chronic, short–term, etc.

OTHER IDENTIFIED NEEDS ARISING FROM QUESTION 1

In addition to the above points outlined as key issues of priority by all four working groups, several needs and/or recommendations were suggested by some of the working groups as follows:

– The need for the development of in situ toxicity tests.

In situ toxicity tests, e.g., the use of indigenous species or caged organisms placed in the natural environment, reciprocal transplants of species from "clean" to "dirty" areas, etc., were favoured for a number of reasons. Such tests can integrate exposure over time whereas chemical tests can only represent one point in time. In situ tests can be conveniently combined with residue measurements. In addition, such tests are conducted in the field and therefore measure the effects of mixtures of chemicals under natural conditions. There are at present few such tests in the regulatory framework. It was recommended that more in situ tests be developed and standardized.

– The need for objectivity, practicality and cost–efficiency.

When a biological toxicity test is required by regulators, the precise objectives of that test should be described clearly and in enough detail so that the users/operators know what the test does and why it is being utilized.

Regulators should not impose mandated tests on industry before the necessary capability to undertake the tests is in place. This requires sufficient advance warning to ensure that new tests can be accommodated prior to promulgation of regulations. It was suggested that this could be achieved by government using the strategy of "technology forcing regulations" in which a regulation is issued with a schedule for compliance which recognizes that increased pollution abatement process modifications or effluent treatment may be required.

For consistency and regulatory fairness, there should be some assurance that regulations or standards will remain unaltered for a reasonable period of time to allow industry to bring tests on–line. However, the regulatory framework must be flexible enough to permit the replacement of existing biological tests with newer tests as best available technology is improved over time.

A series of elaborate and sophisticated tests may not be necessary under a given set of conditions. For example, in the case of effluents that are known to be acutely toxic, regulation of the effluent may require only acute lethality testing. The benefits of this approach include a more efficient use of resources and regulation effort but there is a disadvantage in that more subtle, sublethal or chronic effects could be missed.

Every effort should be made to develop tests that are cost–effective. However, a note of caution must be inserted here that a consideration of costs cannot and should not dominate the scientific and regulatory needs for protection of the environment.

With appropriate justification and under certain conditions, the possibility exists that certain tests could be replaced by surrogate tests or comparative biotests. For example, if an algal test is found to repeatedly agree with a fish test for a particular contaminant, and, there is a saving in time and money if only the algal test is conducted, then the algal test could be used as a surrogate. It must be stressed, however, that if the relationship is not a strong one, the use of surrogate tests could have severe drawbacks and adequate protection of the environment may not result.

– The need for the development of rapid in–plant monitoring systems.

There is a need for the development of in–plant monitoring systems which can respond rapidly to a plant upset or spill in order to allow corrective measures to be taken quickly. Ideally, tests must be developed which can be automated or placed directly into a process control system, i.e., microbiological tests or biosensors.

Question #2. What should be the role of government laboratories in biological testing and monitoring research and development?

5. The Federal government must maintain a strong research and development capability to support its in–house activities and must continue to transfer biological testing and monitoring technology to the private sector.

The Federal government is responsible for regulations under CEPA for the use of biological toxicity tests. To support its role, the government must maintain mission–oriented research programs in this area. This is necessary to ensure that government laboratories have expertise in biological toxicity tests and to maintain "state–of–the–art" research as well as viable in–house programs. In addition, government must be qualified for the necessary role of auditing biotests conducted in the private sector. The participants consider that current government R&D in this field is understaffed and underfunded and cannot be fully effective without additional resources.

Research and development is not the perogative of government. Researchers in universities and within the private sector should be encouraged to collaborate with the Federal government in the development of biological toxicity tests. Contracts should be assigned and funded to those with specific capabilities and expertise. The establishment of Centres of Excellence was discussed as one way to develop certain types of biological toxicity tests.

Biological assessment and testing technology developed by government should be transferred to the private sector. The private sector should have the opportunity to exploit such technology with the government remaining as an auditor for QA/QC.

Neither government nor university laboratories should enter into competition with the environmental service sector by providing biological monitoring or testing services to industry on a routine basis. Government's role in this area should be to provide QA/QC assistance, perform audits and to supply its own program needs.

Question #3. Should government have a QA/QC role in regulatory programs where biological testing and/or monitoring is a component?

6. The Federal Government should provide guidance and show leadership and in the area of biological testing and monitoring (QA/QC), e.g., policies, guidelines, laboratory accreditation, toxicologist certification, etc.

Strong QA/QC programs are essential to validate the results of laboratories in both the private and public sectors. Such programs would result in laboratory certification to identify those laboratories which have demonstrated reliability and reproducilibity. The certification of toxicologists in Canada would be a spinoff from this program. This would increase the credibility of the results of testing.

It was strongly recommended that the Federal government should provide a lead role in all QA/QC for biological toxicity testing services. As well as providing very specific protocols for biotests, government should provide a manual of Good Laboratory Practices and enforce these practices. Self–assessment should be the rule within industry but the government should be responsible for periodic auditing.

QUESTION #4. What role should government play in ambient bio–effects assessment?

7. Government should be responsible for the maintenance of long–term ambient monitoring schemes while industry should be responsible for the assessment of immediate areas of impact, e.g., end–of–pipe and mixing zones.

It is the government's role to assess or evaluate the effectiveness of existing regulations in the receiving environment. It is also the government's responsibility to identify emerging or unpredicted problems that need to be addressed by regulatory regimes. Therefore, the government must be responsible for tests to assess the effects of contaminants in ambient waters.

The maintenance of long–term data sets for biomonitoring, state–of–the–environment reporting, and the monitoring of impacts on large areas must be conducted by the government. The only type of assessment that should be the primary responsibility of industry is the assessment of the immediate area of impact around its operation.

Table 1. Commonality and Priority of Working Group Discussion/Conclusion Statements

	Working Groups			
	1	2	3	4
QUESTION #1 INDENTIFIED NEEDS				
- need to develop a program framework and policy statements required for the setting of biology-based regulatory standards	X	X	X	X
- need to expedite the development of standardized protocols for biological toxicity tests for regulatory purposes	X	X	X	X
- biological testing and monitoring must be integrated with chemistry in a multi-disciplinary manner when applied in hazard assessment and regulatory control approaches	X	X	X	X
- sublethal and chronic tests need to be developed to provide more sensitive monitoring tools for detecting toxic effects in ambient waters	X	X	X	X
- need to improve communication, awareness and an understanding of the applied uses of biological toxicity testing and biomonitoring amongst the public, the scientific community, the regulatory agencies and industry	X	X	X	X
- need consistent regulatory test requirements for biological testing		X	X	
- more flexible, site-specific biological testing and monitoring procedures are required to compliment standard protocols for ambient water impact assessment		X		X
- deal with acute lethality more effectively to eliminate sublethal effects (keep-it-simple princple)		X		X
- develop better, more cost-effective surrogate screening procedures for waste-water toxicity testing	X	X	X	
- develop rapid in-plant biological testing monitoring tools	X		X	
- need for a flexible framework to allow for revision/replacement of standardized biological testing protocols as the need occurs	X		X	
- ensure regulatory fairness		X		
- practicality must be considered in introducing biology into a regulator framework		X		
- acute/sublethal ratio concept should be examined further		X		
- need to clarify nomenclature/definitions (e.g., medical vs. environmental)			X	
- field validation of toxicity tests should be required				X
- private sector want some advance warning prior to government imposing biological testing requirements in regulation	X			
- government shouldn't be involved in biological toxicity testing/monitoring for routine regulatory compliance				X
- need to define regulatory mechansim(s) for ambient water protection (e.g., NPDES permits program)		X		
- distinction should be made between ambient and wastewater type biological tests		X		
- need to develop standardized in situ toxicity tests for use in a regulatory framework		X		
QUESTION #2				
- federal government must maintain a strong research and development capability and continue to transfer technology developed in the fields of biological testing and monitoring to the private sector	X	X	X	X
- the decision as to who should lead R&D programs (e.g., government, university or private sector) should be based on competence and expertise	X	X	X	
- establish centres of excellence for biological testing and monitoring	X	X		
- use polluter fines to pay for R&D (e.g., polluter pays principle)		X	X	
QUESTION #3				
- the Federal government should provide guidance and show leadership in the area of biological testing and monitoring QA/QC (e.g., policies, guidelines, toxicologist certification, lab accreditation, etc.)	X	X	X	X
QUESTION #4				
- government is responsible for the maintenance of long-term ambient monitoring schemes while industry is responsible for the assessment of immediate areas of impact (i.e., end-of-pipe mixing zones)	X	X	X	X
- it is the government's responsibility to assess the effectiveness of existing regulations	X	X	X	
- government should establish a standard DOE reporting format			X	X
- environmental quality objectives need to be better defined and identified		X		
- need for a better understanding of receiving water impacts		X		

APPENDICES

APPENDIX A

Alliston Workshop Program

PROGRAM

BIOLOGY IN THE NEW REGULATORY FRAMEWORK FOR AQUATIC PROTECTION

APRIL 26 – THE REGULATORY FRAMEWORK

MORNING: Plenary Session

10:30–11:00 – Opening Remarks (E. Ongley)

Canadian Environmental Protection Act

11:00–11:30 – legislative overview (B. Wilson)
11:30–12:00 implications for biological testing and assessment (G. Sergy)

AFTERNOON: Plenary Session

Science of Biological Effects Assessment

13:20–14:00 – historical overview of (P. Wells) the development of biological effects assessment

14:00–14:30 – examples of benefits and limitations of biology in the regulatory sphere (R. Scroggins)

MISA

14:30–15:00 – overview of the Ontario MISA Program (J. Bishop)

15:00–15:20 (Coffee Break)

15:20–15:50 – proposed application of toxicity testing and effects monitoring (G. Westlake)

Pest Control Products Act

15:50–16:20 – overview of legislative framework (F.A. Yan Chen)
16:20–16:50 – specific biological considerations (H. Lerer) re water quality and hazard assessment

EVENING:

19:00–20:00 DINNER (Room #15)

20:00–20:30 "U.S. experience in Biological Assessment for Aquatic Protection (N. Thomas)

APRIL 27 – PRIVATE SECTOR PERSPECTIVES ON THE USE OF BIOLOGY IN REGULATION

MORNING: Plenary Session

Regulated Industries

09:00–10:30 – issues and concerns of three major regulated industry groups: Shell, Stelco, May & Baker (D. Bisset) (A. Schuldt) (A. Jones)

Laboratory and Consulting Sector

10:50–11:50 – issues, concerns and opportunities environmental consultants and testing laboratories: BEAK, B.A.R. (K. Schiefer) (C. Wren)

APRIL 27

AFTERNOON: Working Sessions

13:00–18:00 Four concurrent discussion groups representative of a broad spectrum of stakeholders.

1. Benefits and limitations of biological testing and assessment?

- cost, uncertainty, integrated chemical/biological protocols, knowledge, liability, etc.
- effluent testing
- sediment/water/biotic interactions
- residue measurement
- ambient in situ testing and assessment (organism/sub–ecosystem)

2. What should be the role of R&D in government?
- advisory
- privatize and compete

- partnership with industry (e.g., competitive position of Canadian environmental industry in free trade)

- partnership with universities
- technology transfer

3. What role should government play in QA/QC for compliance and assessment?
- self–assessment by industry
- laboratory testing programs (e.g., contract toxicity test services)

4. What role should government play in monitoring and assessment?
- who should do it – industry or government, or
- combination
- advisory role
- *protocol development*

EVENING:

19:00–20:30 Dinner

20:00–20:30 "Stress specific diagnostic indicators and cumulative ecosystemic indicators" by H. Regier

APRIL 28 – WORKSHOP SUMMARY

MORNING: Plenary Session

Workshop Closure

09:00–10:30 – Presentations by Discussion Group Rapporteurs	(D. Carlisle) (K. Day) (H. Eisenhauer) (P. Stokes)
11:00–11:30 – Concluding Remarks	(R. Thomas)

APPENDIX B

Extended Abstracts of Presentations

THE CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA)

by
J. Brian Wilson, Associate Director
CEPA Office
Conservation & Protection
Environment Canada
Ottawa, Ontario
K1A 0H3

Over the past 5 years, the public perception of environmental quality as an important national issue has been growing in Canada to the point where it now rivals the major economic issues of the day. Over the same period, the federal government has been working hard to lay the foundation for the enhancement of our environ mental laws – especially in the area of toxic substances.

In June of 1987, the Minister of the Environment introduced the first major federal environmental statute in Canada in almost a decade – the Canadian Environmental Protection Act (CEPA). The Act represents both a consolidation of some of the major existing environmental protection authorities of the Minister of the Environment and a charting of new directions for federal environmental law.

The Act begins with a strong policy statement linking protection of the environment and the protection of the life and health of Canadians. The first sentence of the Act states that "the protection of the environment is essential to the well-being of Canada". CEPA backs up this declaration by providing no less than 71 opportunities for the Canadian public to receive information generated through the Act and to participate directly in the administration of the Act. Such rights of access and redress include:

- the right to be informed about proposed regulations and enforcement activities and about the health and environmental impacts of toxic substances
- the right to seek a review of regulations under CEPA
- the right to ask that a board of review be established and the right to present an intervention before that board
- the right to request that a suspected toxic substance be included on the Priority Substances List for assessment
- the right to ask for an investigation of a suspected violation of CEPA and to be informed of the results of the investigation, and
- the right to seek a court injunction if it is suspected that individuals or their property may be damaged as a result of a violation of the Act, and the right to sue if damage does occur.

The Act also includes the first-ever definition of "environment" in a federal statute. The "environment" is defined as encompassing air, land, water, all layers of the atmosphere, and all organic and inorganic matter and living organisms. And by including the phrase "interacting natural systems", the definition also embodies an ecosystem approach to environmental protection.

The impetus for CEPA derived from two major areas of concern. First, there existed a clear need to adopt a more comprehensive and preventive approach to the management of toxic substances. This new approach is often referred to as "life-cycle" or "cradle-to-grave". Second, there existed very obvious deficiencies in existing legislation, particularly the Environmental Contaminants Act. Environment Canada could not require importers or manufacturers to properly test new chemicals, did not have the power to collect information on new chemicals from all sources, had no authority to recall toxic substances from the marketplace, and had only limited emergency powers to deal with toxic substances in the environment.

The new Act is a consolidation of the Environmental Contaminants Act, the Clean Air Act, the Ocean Dumping Control Act, Part III of the Canada Water Act, and Section 6(2) of the Department of the Environment Act. But it is more than just a patchwork of old legislation. The new Act permits the control of all phases of the life cycle of toxic substances in order to protect human health and the environment. It requires the formulation of environmental quality objectives, environmental quality guidelines, release guidelines, and environmental codes of practice as a basis for defining environmental protection and environmental quality standards in Canada. In enables the regulation of federal activities, works, and undertakings to ensure that the federal government's own house is in order and that federal departments and agencies lead by example, and it imposes thorough new penalty provisions which are much more in line with the real costs of environmental pollution.

The new Act is not, however, a consolidation of all federal legislation related to environmental protection. For example, the Pest Control Products Act, the Transportation of Dangerous Goods Act, and Section 33 of the Fisheries Act are neither changed nor incorporated into CEPA. Existing administrative arrangements for these Acts will continue. But while CEPA, in its present form, may not yet be all encompassing, the present Act does provide a very strong basis for further growth and development. It is anticipated that in the coming years the Act will be broadened in scope and expanded in content until it becomes a legitimate piece of omnibus environmental legislation.

CEPA is divided into 8 parts (Table 1).

Part I: Includes provision for the creation of environmental quality objectives, release guidelines, environmental quality guidelines, and environmental codes of practice for achieving desirable levels of environmental quality. For example, Environment Canada is presently developing codes of practice to deal with such problems as leaking underground storage tanks and the safe decommissioning of industrial sites. In cooperation with the provincial governments, Environment Canada has also recently established Canadian Water Quality Guidelines. Part 1 of CEPA also provides for research, monitoring, and pollution control programs as well as state-of-the-environment reporting.

Part II: Controls toxic substances from their introduction in Canada, either through importation or manufacture, to transport, distribution, storage, use, release to the environment as emissions or effluents, and ultimately to disposal as waste. For the purposes of this Part of CEPA, a substance is deemed toxic if it is entering or may enter the environment in a quantity or concentration or under conditions:

a) having, or that may have, an immediate or long-term harmful effect on the environment;

b) constituting, or that may constitute, a danger to the environment on which human life depends; or

c) constituting, or that may constitute, a danger in Canada to human life or health.

CEPA dramatically improves government's ability to control the release of toxics into the environment by providing for a broad regulation–making power to enable a "cradle–to–grave" management of toxic substances. With CEPA, for example, there should be no new Sydney Tar Ponds in Canada and the potential for major environmental accidents, such as occurred in Bhopal, India, will be severely curtailed.

Part III: Deals with nutrients such as phosphates used in water conditioning and cleaning products. In the early 1970s, the federal government imposed restrictions on the amount of phosphates allowed in detergents. This has led to a significant recovery of Lake Erie where excess algal growth had been such a problem that the lake had been labelled by some as "dead".

Part IV: Regulates federal works and undertakings so as to ensure that the federal government's own operations and decisions reflect the highest level of environmental protection, and that the federal government is also seen to lead by example. For example, Part IV will ensure environmentally sound waste management and sewage treatment in our national parks.

Part V: Is concerned with controlling sources of air pollution in Canada where the air pollution affects another country or where a violation of an international agreement could result. Examples of such pollution include acid rain and the fallout from municipal and industrial incinerators.

Part VI: Contains provisions relating to the protection of marine environmental quality. It enables the federal government to control the dumping of toxic substances at sea as part of Canada's commitment to protecting marine environmental quality through the international London Dumping Convention.

Part VIII: Contains all of the general application provisions related to such matters as powers of inspectors, boards of review, and penalties. Part VII is what is called the "get tough with polluters" section of the Act.

Part VII: Is strictly administrative, respecting those pre–existing pieces of legislation which are being incorporated into the new Act.

As is evident, CEPA has a strong focus on the management of toxic substances. There are about 65,000 chemicals in existence around the world and approximately 30,000 of these are currently in use in Canada. The CEPA strategy to manage these toxic substances is 3–fold:

1. The life–cycle approach being taken in the management of toxic substances will provide the ability to regulate at each stage of a substance's life cycle. The life cycle phases which may be regulated under CEPA Include:

- research and development
- manufacture and processing
- import and export
- packaging and labelling
- introduction to the marketplace
- storage, handling, transportation and distribution
- advertising and sale
- use
- release to the environment
- disposal

2. The federal government will take steps to come to terms with the toxic substances now in the Canadian marketplace – those thousands of substances about which we often know so little.

a) The government is initiating its work on existing toxic substances by identifying, through an advisory panel of academic, community, labour, industry, and environmental experts, the 50 substances in Canada which most need to be assessed for their environmental and health impacts and which may most need to be regulated. This list will be the core of the existing substances program and will be re–evaluated and updated regularly.

b) As well, Canada has joined with the Organization for Economic Cooperation and Development (OECD) to develop an international program whereby each nation analyses a number of existing substances and shares the results of those analyses with the others. While this is a major undertaking, the payoff could be substantial.

3. The federal government will also regulate the introduction of new substances. Under CEPA, new substances must be assessed prior to their introduction into this country, and once introduced they may be controlled to minimize or prevent any contamination of the environment. In the past, it was up to the government to determine, after the fact, if new substances were environmentally safe and substances were often assumed to be safe until proved hazardous. Examples include polychlorinated biphenyls (PCBs) in electrical equipment, chlorofluorcarbons (CFCs) in aerosol containers, and lead in gasoline. Under CEPA, all new substances being proposed for introduction into Canada must be tested by industry and the data submitted to the federal government for detailed evaluation. The data will include physical and chemical properties as well as information on toxicology, bioaccumulation, persistence in the environment, and susceptibility to chemical changes and interactions in the environment. With this information, the government will be in a much better position to determine the health and environmental risks and the acceptability of a substance before it is allowed to enter into, or be manufactured in, Canada.

One of the areas of CEPA which has attracted particular attention is offences and punishment. The enforcement and compliance policy being developed for CEPA will be one based on fairness and consistency. The emphasis, as in the past, will be on promoting compliance, but offenders will be prosecuted vigorously. CEPA provides tough new penalties and a broad range of sanctions for use by the departments and by the courts.

In Canada, responsibility for the environment is, constitutionally, a shared jurisdiction between the federal government and the provinces. CEPA provides a Canada-wide framework for environmental protection which can be delivered jointly by the federal and provincial governments in a manner defined by bilateral agreements. For example, the standards established by the federal legislation can be enforced by a provincial government provided that government has equivalent control measures in place. In this way:

1) a strong and consistent enforcement of the Act can be ensured,
2) duplication and overlap of effort can be minimized,
3) industry will be spared the problem of duplicate or competing regulations,
4) pollution havens will not be allowed to develop,
5) all Canadians will be guaranteed an equivalent level of environmental protection.

within the 149 sections of the Canadian Environmental Protection Act, there are 27 major and directly-pertinent roles for biologists. CEPA brings a strengthed ecological perspective to the management of toxic substances in Canada. It is only reasonable, therefore, to expect that the decision makers and the implementors will be prepared to embrace this ecological perspective in reaching decisions. But:

a) few of the decision makers will be biologists themselves,

b) decisions will continue to be made on the basis of information arising from a host of pragmatic factors; scientific as well as socio-economic, and

c) the timing of decisions will be determined by a wide range of factors, only one of which is the ecological consequences of each decision.

It is therefore incumbent upon biologists to:

a) take the initiative to bring to the decision-making process their knowledge, results, assessments, and recommendations. Biologists who wait to be asked may well be disappointed and the decisions made may well be the poorer for their lack of involvement.

b) plan ahead so as to be fully prepared when the opportunity to influence decisions arises. There is little value in claiming insufficient data or in tabling new information after all the decisions have been made.

c) identify the most effective point of influence in the system well in advance of any decisions. There is no point in presenting an impassioned and persuasive intervention in one office while the real decisions is being made next door.

d) ensure that interventions are focussed and succinct, and that recommendations are practical and constructive. The counter-arguments certainly will be. The real strength of an environmental intervention will lie in the tabling of practical solutions to environmental problems.

The Canadian Environmental Protection Act provides a challenging and exciting new opportunity for biologists in all sectors to significantly influence the manner in which toxic substances are managed. It is hoped that all biologists will grasp that opportunity and thereby make a significant contribution to environmental protection in Canada.

Table 1. The Canadian Environmental Protection Act (CEPA)

- Declaration
- Preamble
- Administrative Duties
- Definitions
- Advisory Committees
- Part I – Environmental quality objectives, guidelines and codes of practice
- Part II – Toxic substances
- Part III – Nutrients
- Part IV – Federal departments, agencies, crown corporations, works, undertakings and lands

- Part V – International air pollution
- Part VI – Ocean dumping
- Part VII – General
- Part VIII – Consequential amendments and repeal

- Part IX – Coming into force
- Schedule I – List of toxic substances
- Schedule II – List of prohibited substances

– List of toxic substances requiring export notification

– List of hazardous wastes requiring export or import notification

- Schedule III – List of prohibited substances (ocean dumping)

– List of restricted substances (ocean dumping)

– List of factors (ocean dumping)

OPPORTUNITIES FOR BIOLOGY IN THE CANADIAN ENVIRONMENTAL PROTECTION ACT

by

Gary Sergy
Conservation & Protection, Environment Canada Twin
Atria #2, Rm 210
4999-98 Avenue
Edmonton, Alberta T6B 2X3

INTRODUCTION

The Canadian Environmental Protection Act (CEPA), and its Regulations, contain both mandatory requirements and discretionary opportunities for biological testing and assessment. These exist for government (both federal and provincial) and the proponent, and for the consulting and academic sectors who may service the needs of government. Provisions for the application of biological sciences can be found in a wide cross section of environmental protection and management activities required to implement the Act.

In the following material I have identified with CEPA, the major clauses of potential relevancy and provided a personal interpretation of where biology might or must be used.

NOTE TO READERS: This document was prepared prior to final reading of the Act.

PART 1: ENVIRONMENTAL QUALITY OBJECTIVES, GUIDELINES AND CODES

Environmental Data and Research

Section 7 provides opportunity for the Minister to:

- operate a system of routine environmental quality monitoring stations;

- conduct research and studies on environmental pollution (nature, fate, effects,

control, abatement) and provide information and advice thereon;

- conduct research and studies relating to environmental contamination arising from disturbances of ecosystems by human activity;

- formulate plans for, and demonstrate, control technologies;

- and publish and report data on environmental quality and the control and abatement of pollution.

Presumably, an objective of the first activity is to identify long-term changes or trends related to the fate of contaminants or to the general health of the environment. In the context of a monitoring network, the benefits of biological tools would vary with the nature of the network. They may for instance provide an effective screening mechanism to signal orindicate the existence of potential problems, or the need to proceed to more definitive (and costly) analysis.

The second and third activities, are directed more toward assessing pollution in general, both the hazard of substances and ambient environment effects. Such an assessment could help delineate the importance of a concern and define the nature of the corrective measures required. This process of assessment and evaluation would benefit from a broad variety of toxicological and biomonitoring information. The fourth activity (and parts of the second) are directed toward the development and evaluation of treatment technology and disposal methods. In this regard, biological testing can be used: (1) to identify toxicity (for example in-plant sources, or the presence in sludge residues or leachates); (2) to compare wastewater treatment options, residue treatment and disposal alternatives and; (3) to evaluate treatment systems for toxicity reduction efficiency.

Formulation of Objectives and Guidelines

Section 8 requires the Minister to:

- formulate environmental quality objectives, guidelines, release guidelines, and codes of good practice,...for the environment, for substances in the environment, for activities that may affect the environment and for the conservation and sustained use of natural resources.

These 'environmental criteria or standards' would presumably be related to desirable levels of environmental quality and to environmentally sound operational practices. In both the development and definition of these standards, biological tools should have a major role.

Narrative environmental quality standards can be described, or assessed or monitored in biological terms. Numerical environmental quality standards (quantitative) can be derived from toxicity testing data...or a toxicity value itself can be defined as a discrete parameter.

Pollution control strategies can be based on criteria that relate to the quality of water, biota, sediments, etc., that must be maintained for a designated use. Biological assessments are required to determine the maximum allowable inputs that will ensure the desired levels of environmental quality are met.

PART 2: TOXIC SUBSTANCES

Information Collection Powers

Section 14 provides the Minister with opportunity to:

- collect data and conduct investigations on a substance, with respect to:
- its nature and presence in the environment
- environmental and human effects
- environmental dispersion and persistence
- its ability to bioaccumulate and interfere with biological processes
- methods of controlling its presence
- methods for testing the effects of presence in the environment
- use patterns, alternatives for its use and methods of reducing its entry to the environment
- and to evaluate, publish and advise on the above information and recommend control measures

These provisions allow for general research and data gathering and an opportunity for the biological assessment of substances which are not yet scheduled or regulated. All studies would be substance driven, that is they would focus on a specific substance, as opposed to any substance or general environmental pollution. All studies would be done expressly for the purpose of assessing whether a substance is toxic, or is capable of becoming toxic, or for the purpose of assessing the need for measures to control a substance.

In the context of the Act, the major role of biological tools could be threefold. The first would be the identification of potential concerns in order to set priorities for further action, e.g., the first level of activity to assess if a substance is toxic. The second would be to assess the health and environmental hazard of substances in order to determine if control is necessary, e.g., detailed assessments of Priority Substances List. The third would relate to the development and evaluation of control and cleanup technology.Further information on collection powers is found in Section 17. The proponent is required to conduct toxicological and other tests specified by the Minister in situations where the Minister has reason to suspect that a substance is toxic, or is capable of becoming toxic, or for the purpose of assessing whetherto control, or how to control, the substance. While the exact nature of the tests is unspecified, it is logical that they would be consistent with those required for new substance notification (Section 25) and with the biological assessment data gathered under Section 14.

Clearly, Section 14, in combination with Section 17, allows the Minister to investigate or ask for a broad range of material, including a great deal of information of a biological nature.

New Substances

Section 25 requires the proponent to submit prescribed information, about substances new to Canada. These information requirements can be specified in regulation. The draft New Substances Notification Regulations (of December 9/87) thus contain a mandatory requirement for biological testing.

For new substances other than biotechnology products or polymers, the nature of the information depends on how much is manufactured or imported and what list the substance is on. The requirements of a "full" information disclosure would include test data on;

- fish and daphnia acute toxicity (including LC50 and no-effect level results)
- mutagenicity – biodegradation and bioaccumulation
- acute mammalian toxicity
- skin irritation and skin sensitization
- and repeated dose toxicity

The conditions and procedures to be followed in developing test data on the substances are those set out in the OECD Guidelines for Testing Chemicals, or equivalent conditions or test procedures as may be approved by the Minister. An exception are the procedures for the mutagenicity tests, which are specified in the regulations.

For biotechnology products, different types of test data are requested. The requirements include data on: the characteristics of the organism itself; on environmental risk (such as toxicity and pathogenicity to animal and plants and environmental behaviour in microcosms); on field trial results; and information on the sites of environmental application.

The Minister is required to assess data (Section 27) which is submitted on new substances. It is therefore necessary to establish the criteria used in defining and deciding what is an acceptable risk or hazard.

The Minister also has the opportunity to request additional information or testing in order to assess toxicity (Section 28). It is assumed that this additional information would be consistent with the data requirements recommended by OECD, and with the data needs outlined in Section 14.

Toxic Substances Regulations

Under Section 33 the Minister has the opportunity to make regulations with respect to substances on the List of Toxic Substances. These regulations can impose a broad spectrum of requirements on the proponent with respect to such substances. Included are the methods and the conduct of sampling, analyses, tests, measurements and monitoring of the substance.

Biological tools should find their way into such regulatory requirements as they have elsewhere. Toxicity itself can be regulated as a generic pollutant. Whole effluent toxicity control is well recognized to overcome a large number of problems inherent in other types of approaches. Biological testing can also correlate releases and actual receiving environment effects. Biological monitoring may be used to track the fate and behaviour of a substance in the ambient environment.

Fuels

Section 45 gives the Minister opportunity to make regulations about the production or import of fuel. These would require the proponent to submit information regarding the adverse effects on the environment, or on human life or health, from fuel combustion.

PART 4: FEDERAL DEPARTMENTS

Sections 51 and 52 provide opportunity for the minister to:

- establish environmental protection guidelines for use by federal departments, boards, agencies or crown corporations
- make regulations prescribing limits on the release of emissions and effluents and waste handling and disposal practices for departments, boards and agencies
- and in the absence of other legislation, make environmental regulations for federal lands, works and undertakings

These provisions could be exercised such that biology is utilized in the development and definition of environmental rules for the government itself.

PART 6: OCEAN DUMPING

The Ocean Dumping Control Act has been consolidated into CEPA. Biological testing and assessment would focus on the determination of specific permit conditions, as well as setting priorities and evaluating the effectiveness of previous control measures.

Section 69 requires the proponent to submit information, as prescribed or required by the Minister, in support of a permit application. The information requirements or methodology may be described in regulations. In the permit assessment process, the Minister is obliged to take into account a list of factors (Schedule III, Part III of the Act). Many of these are of a biological nature e.g., toxicity, bioaccumulation, tainting, effects of previous dumping, possible effects on marine life and resources, etc.

PART 7:
GENERAL (Enforcement andCompliance)

The government will be required to use biological tests and procedures in enforcement and compliance activities. For example, a variety of offenses of Part II (Toxic Substances) would require such testing in order to detect and demonstrate non–compliance and/or fraudulence. There is often a requirement to establish liability and provide information which can assist the courts in determining appropriate penalties for violations. Knowledge pertaining to the nature and gravity of the offence...about potential or real environmental damage, can therefore be vital. This can range from the demonstration of toxicity in lab testing to the documentation of actual impact by field biomonitoring.

ADEQUACY

A final but important task, in which biology has a role, pertains to the question of adequacy...the evaluation of the effectiveness of control measures and remedial actions in protecting the environment. This information is an essential feedback to assess earlier decisions, and if need be, modify them accordingly. Provisions for such activity can be found in the obligatory review cycle built into CEPA, and indirectly in various other places in the Act.

SUMMARY OUTLOOK

The Canadian Environmental Protection Act allows for the application of physical, chemical and biological sciences, and environmental technology, in order to achieve and maintain a desirable state of environmental quality.

Both the spirit and letter of the Act provide for biological testing and assessment. In some cases it is demanded, but in more cases there is simply a provision of opportunity. The ultimate quality and quantity of 'biology' to be used in implementing CEPA, is very open to interpretation and initiative.

Although there is no shortage of opportunity, the magnitude of actual use does remain to be seen. Historically, opportunity has been poorly exploited. In some cases, the attitudes and actions of scientists has been detrimental.

To a large extent, actual use will depend on demonstrating practical and effective biological approaches! It will depend on convincing 'implementors' to accept biological approaches and understand their value! The role of biology will depend on the biologists' ability to communicate, to apply scientific judgement and to express biological information in pragmatic and useful terms for the decision–maker.

QUESTIONS TO GARY SERGY AND BRIAN WILSON

Q.Martin Samoiloff. Bioquest International Inc., Winnipeg, Man.

In toxicology we have what is called the first law which says "All substances are toxic" with the caveat that you have to find the conditions under which these substances are toxic. In an environmental protection law that focuses on substances, aren't we excluding compounds not listed and also those conditions in which combinations of compounds produce adverse effects on the environment? Are we not excluding conditions that may be really toxic but not specified? And secondly, is the legal framework in Canada such that due diligence always seems to be a pardonable excuse for demeaning the environment? Are we not generating a house of cards, then, with those two components?

A. Brian Wilson

Part of the concept behind CEPA is the development of a couple of lists of substances i.e., a list of domestic substances and a list of non–domestic substances, which will be compiled over the next couple years. If a substance is not found on that list it is up to the user/importer/manufacturer to take the initative to provide the information to government which would enable government to assess the ecological and environmental implications of the use of that substance and the need for control. In addition, the definition for substance is currently broad enough to easily encompass groupings or mixtures of substances and certainly the Priority Substances Committee is considering grouping of substances which would be included amongst the list of 50.

In reference to the second portion of your question, I thought I alluded to that in my talk. Biological testing provides effects monitoring rather than substance monitoring and given the legal situation where due diligence is normally accepted as a reasonable reason to defile the environment, wouldn't it be wiser to have a component of effects rather than substances as a criteria for damage to the environment? That option is very much open in CEPA and I do not think it's a question of one or the other, I think that it is a question of marrying the two effectively.

Q.John Ralston,

Ontario Ministry of the Environment

How does the act deal with those indigenous chemicals that are formed during the manufacturing process or subsequent processes, e.g., deadly dioxins, perilous pH's, etc. Where in the act are they dealt with and how effectively are they dealt with?

A. Brian Wilson

They are dealt with in part 2 of the Act which includes amongst the definitions of substances which can be regulated, by–products that are generated and become part of the complex mixture.

Comment: Gary Westlake, Ontario Ministry of the Environment

I notice that the Fisheries Act was not mentioned and it does not appear to have been incorporated into CEPA. Is this Act being left intact? In addition, I noticed in the Act that there was a statement about limiting "long–term effects" on environments. I wonder if there is any significance in putting it that way, i.e., "long–term effects" as opposed to "effects" specifically? The question of long–term effects is simply a recognition that an evaluation based on a short–term or acute toxicity test has inherent limitations. Hence the need to consider longer–term or chronic evaluations of toxic substances and to put in place monitoring programs which can be very useful in evaluating how effective a regulatory decision is in the long–term. This provides us with a feedback mechanism that enables us to reevaluate regulations and regulatory decisions. Although expensive, I think in the long term that it is very cost–effective.

Comment: Peter Chapman, EVS Consultants and CEAC

You put a lot of emphasis on the Toxic Substances Advisory Panel and I'm not sure that emphasis is warranted. First of all, labour is boycotting that panel and secondly, there is disagreement amongst the members of the group. In addition, the panel will be producing a list of approximately 50 chemicals, and of that list, only 5–10 will be assessed every year. Therefore, we are looking at a time frame of 5–10 years for those 50 chemicals to be assessed and still there are 65,000 more chemicals waiting to be assessed. So frankly, personally and professionally, I think a) that it is inadequate, but b) it opens up a large realm for biology because the definition of toxic chemicals is based on biology. We are talking about mixtures and the only way to assess these mixtures is through some form of biological testing. So I put it this way a) don't rely on the panel and b) the opportunities are wider and more immediate than you are willing to put out.

A. Brian Wilson

I have no disagreement with those comments whatsoever.

Q. An Act is only as good as it can be implemented, not how good it looks on paper. Is the current structure of the Department well–enough suited to implement this particular Act effectively? I have two particular concerns a) where is the effective point where scientific input can be given to the top decision maker and b) I submit that the department is extremely weak in health effects. The bottom line that we all talk about is human health effects, but I do not see as a member of Environment Canada's professional staff that all our biologists can give excellent ideas and data to determine this. In addition, who is going to interpret that data in terms of human health effects and where is that interpretation going to go? I don't see many people from the Department of Health in attendance at this meeting.

A. Brian Wilson

I think that the department has in-place a significant capability to handle the new requirements of CEPA. Initially CEPA is in many respects a compilation of pre-existing legislation. New regulations, guidelines and codes of practice will be developed as we go and therefore we should have some flexibility to grow and adapt. It is clear however that new resources and capabilities will have to be developed both in the areas of assessing existing toxic chemicals and evaluating information that industry will submit in support of new substances and I would not overlook the question of increased attention being placed upon compliance and enforcement.

With respect to the health aspects, I couldn't agree with you more. All that I can suggest is that this legislation was cosponsored by the Ministers of Environment and Health and Welfare, and that the role of the Ministry of the Department of National Health and Welfare is recognized in several points in the Act. The intent is that toxic chemicals will be assessed both from the environmental aspect using the expertise of not only Environment Canada, but the provincial and territorial Environment Departments and from the health perspective, the Department of Health and Welfare and the provincial labour departments.

Q. Don O'Shaughnessy, Chipman Inc.

One of the questions that seems fairly obvious from the pesticide industry is that as the data requirements grow and the proponent as you term it, is required to submit studies, there will be a cost incurred. One of the considerations for example in the PCP Act or at least in the regulations is protection of the propriety data and I am wondering if any thought has been given to protection of data submitted by proponents under CEPA?

A. Brian Wilson

There is a substantial section under Part 2 on Toxic Substances that relates to the protection of confidential business information. That section has been completely overhauled to bring it into compliance or agreement with existing legislation on protection, information privacy, etc. That section is very strong and very consistent with the way that information on pesticides is currently handled by the Department of Agriculture.

Q.Bob Baker, Environmental Protection, Ottawa

I noted in Gary's presentation that for new substances there is going to be an OECD guideline referenced to provide some guidance to proponents that want to bring a new substance to Canada. And hearing that, I thought about the priority 50 substances that would be the existing substances under the Act and I am wondering if existing chemicals will be handled in a similar way as new chemicals?

A. Gary Sergy

What is required for existing chemicals isn't specified as it is for new chemicals, but I would hope that we would be consistent in asking for similar type of information.

Q. Bob Baker

Would it be the intention of the federal government to take the lead at establishing something comparable to OECD guidelines relating to the assessment of existing substances under the Act?

A. Gary Sergy

I don't know what the CEPA office has in mind. The existing chemicals will be covered by Commercial Chemicals Branch within Environmental Protection.

Q.Malcolm Clark, B.C. Ministry of Environment and Parks

Two comments, and then a question. First, I would like to suggest that it is important that health concerns not be interpreted as simply substances that are carcinogenic. I think that is a common error made, especially in North America. Secondly, I think that it may be in error to exclude polymers, because quite a few of these are extremely active and there was no explanation as to why they were excluded. My question relates to what is meant by the word "environment" – this workshop seems to be more water-oriented than air-oriented. Are we talking ground water, is indoor air quality included, etc.?

A. Gary Sergy

I will answer only a part of your question. Polymers are not excluded. Substances were divided into three groups – chemical substances, biotechnology products and polymers. I didn't mention polymers but they are defined and there are information requirements in the new substances notification regulation.

A. Brian Wilson

The attempt in defining environment was to ensure that for a use of this Act, environment was all-encompassing and all components of the physical, chemical and biological environment are considered in assessing toxic substances. The definition of environment does not include indoor air quality, but it includes ground water, water, land, the atmosphere, the biota that exists in the physical and chemical environment, etc.

Q. Randall Mortay, Alberta Environment

Is the intent of biological monitoring to reduce or replace chemical monitoring? I have difficulty in comprehending this. Biological effects can be used to identify the toxicity of single substances on a one-to-one basis because we have cause-and-effect. But when you are going to use this in regulations to monitor effluents which contain a mixture of chemicals which may all be causing effects, it may be difficult to relate cause-and-effect.

A. Gary Sergy

Biological monitoring is to be used in conjunction with chemical and physical monitoring and what I hope to come out of this workshop are some good ideas on how to use the biomonitoring tools that are available to use, but not to the exclusion of other useful tools.

HISTORY AND PRACTICE OF BIOLOGICAL EFFECTS ASSESSMENT FOR AQUATIC PROTECTION IN CANADA: A SYNOPSIS*

** This paper is dedicated to Dr. John B. Sprague, an outstanding Canadian biologist, toxicologist and teacher, upon the occasion of his retirement from the University of Guelph, Guelph, Ontario.*

by

Peter G. Wells
Environmental Protection
Conservation & Protection
Environment Canada

Dartmouth, Nova Scotia B2Y 2N6

INTRODUCTION

Biological procedures are a cornerstone of the broader ecotoxicological approach to the hazard assessment of toxic chemicals and the control of such chemicals alone and within complex emissions. Their objective is to offer, together with chemical and microbiological procedures, protection of aquatic ecosystems at known levels of biological and statistical certainty and interpretation.

Biological techniques have been used informally as investigative tools in Canada since the 1940's. Canada has also played a significant role in the development and application of these techniques both nationally and internationally. In the past two decades, biological testing or ecotoxicological procedures have been formally incorporated into some pollution control legislation in Canada (e.g., regulations and guidelines under the Fisheries Act and various provincial acts). There is every expectation that this will continue in the new climate of the Canadian Environmental Protection Act (CEPA) and Ontario's Municipal Strategy for Abatement (MISA), supported as well by other initiatives, e.g., Fish Habitat Management Policy, DOE's Marine Environmental Quality Management Framework, FEARO's review of ecotoxicology in environmental impact assessment.

It is important to reemphasize the key role of biology and ecotoxicology, together with chemistry, geochemistry and microbiology, in the management and regulation of toxic chemicals and other pollutants. There is a continued need for more practical, standardized, reliable, and predictive techniques for the biological assessment of water pollution and water and sediment quality. It is also important to understand the level of protection offered to an ecosystem by decisions based upon data from a particular biological or ecotoxicological test or suite of techniques. This paper provides a brief overview of the history and practice of aquatic biological effects assessment in Canada and restates the need for interested parties and agencies in Canada to continue to develop, standardize and apply these techniques in water quality and pollution assessment and management.

DEFINITIONS AND CONCEPTS

A number of definitions and concepts are very basic to the discussions that follow both in this paper and in the workshop deliberations. They are as follows and have come from Rand and Petrocelli (1985) unless otherwise noted:

Aquatic environmental research was described by J.R. Weir in 1969 (in Johnstone, 1977) as follows: "It includes studies on all of the biological aspects of oceanography and limnology as they relate to productivity of marine and inland waters and to the fitness of the aquatic environment. It also includes the detection, dispersion and degradation of man-made pollutants in water, the understanding and modification of natural ecological changes and the resistance and tolerance of aquatic organisms to harmful substances. The desirability of preserving a healthy and viable environment introduces the need for proper overall management of all renewable resources within the ecosystem so that its deterioration through such things as pollution can be avoided. This means long-term research and planning to ensure a more efficient, high quality, continuing resource for commercial and other uses that is compatible with demands for human health and enjoyment".

Ecotoxicology was defined by Butler (1978) as "describing the toxic effects of physical and chemical agents on living organisms and especially on populations and communities within defined ecosystems. Ecotoxicology includes an evaluation of the transfer pathways of those agents and their interactions with the environment. Maki (1983) stated that "the basic objective of applied ecotoxicologists is to place the right numbers and kinds of tests with ecologically significant test species into a workable systematic program to enable an early, cost-effective prediction of hazard at an acceptable level of certainty to guide regulatory and industrial decision-making".

Toxicity is the inherent potential or capacity of a material to cause adverse effects in a living organism.

Lethality is that toxicity which causes death by direct action.

Sublethality is that toxicity which causes an effect at concentrations below those that directly cause death.

Exposure assessment is the evaluation of the contact reaction between a chemical or physical agent and a biological system and includes a consideration of the duration of the estimated or expected environmental concentrations likely to occur in the environment.

Hazard is the likelihood that a chemical will cause an injury or adverse effect under the conditions of its production, use or disposal.

Bioaccumulation is a process by which chemicals are taken up by aquatic organisms from water directly or through consumption of food containing the chemicals.

Bioconcentration is a process by which there is a net accumulation of a chemical directly from water into aquatic organisms resulting from simultaneous uptake and elimination.

Biomagnification is the result of the processes of bioconcentration and bioaccumulation by which tissue concentrations of bioaccumulated chemicals increase as the chemical passes up through two or more trophic levels.

Biomonitoring is the use of living organisms as "sensors" of environmental quality, such as in water quality surveillance to detect changes in an effluent or in water quality. Biomonitoring is also used to indicate whether aquatic life may be endangered.

HISTORY OF THE USE OF BIOLOGICAL TESTING FOR ENVIRONMENTAL PROTECTION

This is a brief overview of the history and application in Canada of biological and ecotoxicological approaches in the regulatory process for the protection of aquatic ecosystems. It is complementary to the recent overview paper by Blaise et al. (1988), and is obviously a reflection of the writer's experiences!

Basic toxicological practices were started in a number of countries in the 1800's and major developments in pharmacology, toxicology and applied entomology occurred from that time to the early 1900's. Early work included pesticide testing with insects and water quality testing with cladocerans. By the 1940's and 1950's a number of people, notably Hart et al. (1945),Doudoroff et al. (1951), Cairns and Sprague, were applying simple, practical biological and toxicological techniques to the assessment of water quality problems in North America (Sprague, 1969). By the 1960's, such biological work was being conducted in Canada, the USA, the UK and Europe to acquire data on the acute toxicities of effluents and chemicals from industries and municipalities, and to determine the zones of effects on biota and their habitats for each water body receiving wastes. In Canada, work included studies of pulp mill discharges on the West Coast by M. Waldichuk, detailed studies along the Saint John River, N.B., by J.B. Sprague and environmental physiological/toxicological studies by F.E.J. Fry and students. Valuable information and understanding was thus being obtained on the composition, toxicity potential and field impacts of selected chemicals and effluents, and on the influence of environmental variables such as oxygen, pH and salinity. Such scientific efforts contributed substantially to the moves towards obligatory treatment of selected industrial effluents, demanded through regulations and guidelines, that took place in the following decade.

By the 1970's in Canada, considerable efforts were underway provincially and federally in a parallel effort to develop much-needed water quality guidelines and objectives for specific physico-chemical parameters and chemicals. However, it was recognized in Canada that this was not an efficient approach to the first and urgently needed stages of massive industrial water pollution control; working from the ambient environment back to controls at the pipe was simply too expensive in time, effort and scientific uncertainty of what to control. The water quality approach was also hampered by the continual introduction and use of new chemicals and formulations (e.g., pesticides, dispersants), and the uncertainties of the composition and the cumulative fate and effects of the various mixtures being discharged. The areas of application factors and the relationships between acute and chronic effect thresholds were in their infancy. In the redrafting of national legislation (i.e., the Fisheries Act 1970, 1977), with the redefinition of "fish" and the emphasis on water pollution control regulations and guidelines for each industrial sector, the water-quality based approach to water pollution control took second place to the source emissions/effluents limit/standards approach.

The setting of limits and standards for specific parameters at the end-of-pipe on an industrial sector basis, through guidelines and regulations under the federal Fisheries Act, became the federal strategy in Canada for controlling industrial effluents. This approach involved and was supported by industry and the provinces. The intent was to control the worst polluters first, through broad controls based on best practicable technology. The intent was that the effectiveness of the general National limits and standards was then to be determined on a plant–by–plant, site–by–site basis, looking at the end of pipe and receiving waters, with adjustments to be made (Pessah and Cornwall, 1980; Wells, 1980). In summary, the first strategy was an emissions–standards one, to be followed by an integrated, emissions–standard/environmental quality approach at each location.

This first step required an aquatic toxicity protocol (i.e., a legalized standard procedure) and specific toxicity criteria for a number of regulations and guidelines (Pessah and Cornwall, 1980). Hence the rainbow trout acute lethal toxicity test was developed, standardized and adopted. The objective was to improve final effluent quality so that fish could survive in full–strength effluents, or allowable dilutions calculated for each industry, for four days with toxicity being measured as a 4–day LC50 (median lethal concentration) or an LT50 (median lethal time) at a designated concentration. The application of a relatively simple and legally acceptable acute toxicity test for controlling effluent quality, together with physico–chemical characterization of the effluent and limits on other key parameters, was the first coordinated step to reducing serious water pollution from industry in Canada. Today a standard procedure with rainbow trout exists (Anon., 1980) which has been modified and adopted by some provinces (e.g., Ontario, B.C.) for effluent control under provincial regulations and is generally, but not exclusively, the aquatic toxicity test of choice for legal testing at the present time.

By the late 1970's, considerable work was underway on the second stage of applying biological tests in the regulatory process. Work included the study of acute toxicity reduction within waste treatment systems (e.g., potato processing plants and mining operations in New Brunswick), studies of the sublethal toxicity of untreated and treated effluents (e.g., refinery effluents, see Westlake et al., 1983), and extensive sublethal studies of pulp and paper mill effluents in receiving waters (e.g., northern Ontario rivers, Howe Sound in B.C.). Resources and consequently the efforts were limited, and the era of deregulation had begun, but a number of excellent studies in Canada contributed to the planned second step of more closely examining and controlling effluents.

The emphasis also started to shift by the late 1970's to chemical, microbiological and biological studies of "priority toxic chemicals" in receiving waters near industrial outfalls and sites e.g., cadmium from lead smelters; PAH's from aluminum smelters and coke ovens at steel mills; PCB's near fish plants; chlorophenols and associated dioxins from wood preserving plants; etc. Fortunately, research on a wide range of sublethal toxicity procedures was underway e.g., blood and enzyme responses in salmonids; reproduction and development in cladocerans; bioaccumulation in microalgae, etc., that could be applied to non–lethal effluents and their receiving water dilutions, or to widely–used chemicals and their formulations. During this period, extensive work continued in some laboratories on marine toxicity procedures, developing acute lethal and sublethal tests with teleosts, molluscs, crustaceans and echinoderms, as well as some field monitoring procedures with fish and invertebrates. Progress in this area in Canada is well described in the Proceedings of the Annual Aquatic Toxicity Workshop, and many water–related journals.

To deal with wastewater discharges now and in the future, environmental protection agencies in a number of countries, particularly in Europe and North America, have recognized and restated the value of applying aquatic hazard assessment principles and procedures to effluents and their component chemicals and properties. Recent examples of such support include the MARTOX Conference Proceedings (Persoone et al., 1984), the 1984 OECD sponsored Workshop on the Biological Testing of Effluents (Environment Canada, 1984), the OECD guidance document on effluents (OECD, 1986), and a recent SETAC Meeting and proceedings on the hazard assessment of effluents (Bergman et al., 1986). The growing application of biological tests for environmental protection, such as is rapidly occurring now in the USA and Europe, can certainly be attributed to their growing versatility, predictability, cost–effectiveness, and interpretive value.

Biological/ecotoxicological testing of effluents via "end–of–pipe" and "receiving water" approaches has served and is serving Canada and a number of other countries well in their efforts to curb aquatic pollution. There is now a better understanding of the applications, advantages and limitations of the various laboratory and field approaches, and it is commonly accepted that biology/ecotoxicology (effects identification) and chemistry (cause identification) are unseparable components of the various hazard assessment approaches being employed or developed (see Blaise et al., 1988).

PRACTICE

Biological procedures of many kinds, including toxicity tests, are being actively built into current policies, frameworks, strategies, guidelines, regulations and codes of good practice in many countries in all continents. The reason is simple – biological tests and toxicological end–points offer rapid, reliable and unequivocal, integrated measures of environmental effects or their potential, for contaminating substances or conditions. Examples for freshwater concerns include the industrial effluent testing framework of West Germany (P. Hansen, pers. comm.); the US EPA Clean Water Act NEPDF Program with the 50 states, where both freshwater and marine acute and chronic tests are being employed for site-specific regulation of wastewaters; the OECD toxic chemical protocols for toxicity testing, and its industrial effluent management plan with components for biological procedures; and the Great Lakes Water Quality Program under the Great Lakes Water Quality Agreement (revised in 1987). On the marine side, there are various marine pollution frameworks that encompass ecotoxicological testing (Wells and Cote, 1988). Examples are the GIPME (Global Investigation of Pollution in the Marine Environment) Comprehensive Plan; the 1985 UNEP (United Nations Environment Programme) "Montreal Guidelines" marine environmental protection framework; the sediment hazard assessment scheme for the Canadian Ocean Dumping Control Act (now incorporated into CEPA); and the monitoring strategies and practices of the NOAA Status and Trends Program of the USA.

A number of recent papers and monographs (see Addison, 1984; MacGregor and Wells, 1984; Wells et al., 1985; Sergy, 1987; Blaise et al., 1988, and ASTM Spec. Tech. Pubs., as examples) have summarized the current approaches to the biological assessment of effluents and chemicals, and receiving waters, sediments and their biota. The approaches are varied. They include subcellular, cellular, tissue and whole organism response measurements; the measurement of population and community changes; simple, single species screening tests in the laboratory; more costly, complex but realistic micro/mesocosm systems; field in-situ measurements and experimental field trials; observations at contaminated sites and on natural populations and communities. There are many testing procedures being researched or being applied, and a number are sufficiently well-understood, reliable and standardized as to have had direct application as standard procedures for a number of years e.g., salmonid and cladoceran toxicity tests, fathead minnow tests, mysid tests, bacterial tests, etc. (see Sergy, 1987 for the Canadian proposed core tests). Others show great promise, e.g., microalgal and microcrustacean tests. Many of these will soon be incorporated formally into hazard assessment and regulatory schemes for chemical and effluent screening, predictive testing, and biological monitoring (Blaise et al., 1988). Many new innovative approaches such as QSAR, Scope for Growth, and the Triad Approach to Assessing Contaminated Sediments, continue to be developed and applied. In summary, it might be said that the limitation is not the availability of biological/toxicological techniques, but the availability of formally standardized, calibrated, and rigorously controlled procedures for immediate general use. This problem is being addressed with some urgency now for laboratory procedures (Sergy, Scroggins Chau and Dutka, pers. comm.) and for marine field effects (Addison and Burns, pers. comm.).

FUTURE STEPS FOR CANADA

Canada has made a considerable contribution to the field of biological toxicity testing and to the applications of these procedures in water quality/pollution assessment, control and monitoring.

However, there is a clear need to continue to develop and to use biological assessment techniques in aquatic protection strategies and control instruments, including regulations. Environmental scientists and managers in various sectors (industry, consulting and government) must keep working together to formally accept and enhance the role of biological testing in the long term management of toxic chemicals, effluents, emissions, hazardous wastes and materials from non-point sources.

It is vitally important that laboratory and field suites of presently available techniques be identified, improved upon, and be prepared as standard methods and protocols for Canadian conditions and issues. At the same time, it is clear that the fields of environmental chemistry and toxicology are rapidly and continually developing, and potentially contributing in new and innovative ways to toxicological and hazard assessments. For the immediate future, therefore, such suites must remain flexible and open to improvement through research.

Finally, biological and ecotoxicological approaches should be used effectively and with flexibility, whenever and wherever possible, to control, monitor and prevent water pollution and reduce long-term, chemically-induced, environmental degradation.

REFERENCES

Addison, R.F. 1984. Marine ecotoxicological testing in Canada – a personal assessment. Pages 163–177 in Persoone et al. (eds.), Ecotoxicological Testing for the Marine Environment, State University of Ghent and Inst. Mar. Scient. Res., Bredene, Belgium.

Anonymous. 1980. Standard Procedure for Testing the Acute Lethality of Liquid Effluents. Environmental Protection Service, Regulations, Codes and Protocols Report EPS 1-WP-80-1. 11 p.

Bergman, H.L., R.A. Kimerle and A.W. Maki. 1986. Environmental Hazard Assessment of Effluents. Pergamon Press, New York, 336 p.

Blaise, C., G. Sergy, P.G. Wells, N. Bermingham, and R. VanCoillie. 1988. Biological testing – development, applications and trends in Canadian Environmental Protection Laboratories. Toxicity Assessment 3 (In press).

Butler, G.C. (ed). 1978. Principles of Ecotoxicology. Scope 12. John Wiley and Sons, New York, N.Y. 350 p.

Doudoroff, P. et al. 1951. Bio–assay methods for the evaluation of acute toxicity of industrial wastes to fish. Sewage ind. Wastes 23:1380–1397.

Environment Canada. 1984. Proceedings of the OECD Workshop on the Biological Testing of Effluents (and Related Receiving Waters), Duluth, MN. September 1984. Environment Canada, Ottawa. 367 p.

Hart, W.B., P. Doudoroff and J. Greenbank. 1945. The Evaluation of the Toxicity of Industrial Wastes, Chemicals, and Other Substances to Freshwater Fishes. Atlantic Refining Company, Philadelphia, PA 317 p.

Johnstone, K. 1977. The aquatic explorers: A history of the Fisheries Research Board of Canada. University of Toronto Press, Toronto, 342 p.

MacGregor, D.J. and P.G. Wells. 1984. The role of ecotoxicological testing of effluents and chemicals in the Environmental Protection Service. A working paper prepared for the Laboratory Management Committee. EPS, Environment Canada, Ottawa. 56 p.

Maki, A. 1983. Ecotoxicology – critical needs and credibility. Environ. Toxicol. Chem. 2:250–260.

OECD. 1987. The use of biological tests for water pollution assessment and control. OECD Environmental Monograph No. 11, October 1987. 70 p.

Persoone, G., E. Jaspers and C. Claus, eds. 1984. Ecotoxicological Testing for the Marine Environment. Vols. I and II. State University of Ghent, Ghent, Belgium, and Institute for Marine Scientific Research, Bredene, Belgium.

Pessah, E. and G.M. Cornwall. 1980. Use of toxicity tests in regulating the quality of industrial wastes in Canada. Pages 130–141 in Aquatic Toxicology, ASTM STP 707. (J.G. Eaton et al., eds.). Amer. Soc. Testing Materials, Philadelphia, PA..

Rand, G.M. and S.R. Petrocelli. 1985. Fundamentals of Aquatic Toxicology: Methods and Applications. Hemisphere Publishing Corporation, New York, N.Y. 666 p.

Sergy, G.A. 1987. Recommendations on Aquatic Biological Tests and Procedures for Environmental Protection, C&P, DOE. Manuscript Report, Environment Canada, Ottawa. 102 p + Appendices.

Sprague, J.B. 1969. Review Paper. Measurement of pollutant toxicity to fish. I. Bioassay methods for acute toxicity. Water Research 3:793–821.

Wells, P.G. 1980. Letter to the Editor. On the Nature of the Canadian Fisheries Act. Mar. Environ. Res. 3:315–318.

Wells, P.G., R. Belore and E. Belore. 1985. Canadian Directory of Aquatic Toxicologists and Related Specialists. First Edition. Environment Canada, Environmental Protection Service, EPS–5/AT/1, March, 1985. Environment Canada, Ottawa, 164 p.

Wells, P.G. and R.P. Ct. 1988. Protecting marine environmental quality from land–based pollutants: the strategic role of ecotoxicology. Marine Policy 12(1):9–21.

Westlake, G.F., J.B. Sprague and D.W. Rowe. 1983. Sublethal effects of treated liquid effluent from a petroleum refinery. V. Reproduction of Daphnia pulex and overall evaluation. Aquatic Toxicology 4:327–339.

USE OF TOXICITY TESTING AND BIOMONITORING IN ENVIRONMENTAL PROTECTION

by

Richard Scroggins
Industrial Programs Branch
Conservation & Protection
Ottawa, Ontario

The application of biological testing and monitoring techniques can be separated into three general classes: toxicity testing, biomonitoring and bioeffects monitoring. As the meaning of these terms may vary, they have been defined below.

Toxicity tests are standardized biological testing procedures which measure the responses of aquatic organisms exposed to samples of wastewater, leachate or ambient waters. The responses of these test organisms can be divided into two categories, rapid effects (acute) or longer term (chronic). The end–point of an acute toxicity test is usually lethality but in some cases sublethality can also be the measured end–point. An acute toxicity test is short in duration (e.g., generally less than 96 hrs). The rainbow trout lethality test is an example of an acute toxicity test. In a chronic toxicity test, a sublethal effect is usually the end–point measured although lethality due to chronic exposure is also possible. The duration of a chronic toxicity test is generally greater than 96 hours and examples of effects commonly measured include reduced reproduction, inhibition of egg–hatching, growth inhibition, etc.

Biomonitoring involves tissue residue contaminant measurement in aquatic organisms which are indigenous or introduced to the ambient environment. Examples of biomonitoring would be the exposure of fish in cages at various distances down–stream of a industrial or municipal wastewater discharge or collection of indigenous organisms (e.g., fish, leeches, clams, etc.) for chemical analysis of the tissue.

Bioeffects monitoring involves the use of biota in the ambient environment at a species, population or community level to assess the health of the receiving environment on a spatial or temporal basis. Assessment of the diversity and density of river bottom invertebrates downstream of an effluent discharge is an example of bioeffects monitoring. In many past and present environmental protection research projects and programs, biological testing and monitoring has been used along with chemistry to solve problems. The advantages of the chemical approach are: 1. individual chemicals can be modelled more easily; 2. carcinogenic, persistent or bioaccumulative substances can be measured numerically, and therefore directly limited, and 3. wastewater treatment systems have been traditionally designed and operated using chemical parameters. The benefits of the biological approach are: 1. the toxicity of all constituents in a complex aqueous mixture are measured together by observing the response of the organisms; 2. a few cost-effective biological tests can quantify the toxic effect of an aqueous discharge; 3. synergistic and antagonistic effects common in complex mixtures can be quantified; 4. the bioconcentration and genotoxic potential of aqueous waste discharges can be assessed directly; 5. the actual impact of an aqueous discharge on the environment can be measured, and 6. responses are the consequence of exposure over time and not instantaneous. A combination of chemical and biological assessment to control aqueous discharges is a logical move as the approaches are complimentary.

The current federal statutes which require, or soon will require, biological testing and/or monitoring include:

- Canadian Environmental Protection Act
- Arctic Waters Pollution Prevention Act
- Canada Oil and Gas Act
- Fisheries Act
- Migratory Bird Act
- International Polar Bear Agreement
- Amendments to the Transportation of

Dangerous Goods Regulations

Using the following three studies as case examples, I hope to explain how toxicity testing, biomonitoring and bioeffects monitoring can be used in environmental problem solving. My first example has been taken from the iron and steel industry. I'll be talking about a wastewater assessment program which was conducted at Stelco's Lake Erie Works (LEW) facility located at Nanticoke, Ontario. LEW is a fully integrated steelmaking facility with an extensive wastewater treatment system which started operations in the summer of 1980. All treated wastewaters and site runoff end up in a stabilization pond with a seven day retention time prior to discharging to Long Point Bay, Lake Erie via a small stream called Centre Creek. Long Point Bay is a very popular yellow perch and smallmouth bass fishing area and major spawning grounds for both species are located in Long Point Bay off Centre Creek.

The question which needed to be resolved in this case was whether or not Stelco's final treated wastewater would have any effect on Long Point Bay aquatic life. The approach taken by Stelco was to hire consultants to conduct an on-site toxicological and chemical monitoring program to evaluate the quality of the final treated wastewater and assist the Ontario Ministry of the Environment (MOE) with their biomonitoring and bioeffects monitoring program in Long Point Bay off Centre Creek. An extensive assessment of the toxicity and chemical contaminant levels in the final treated wastewater was conducted between 1980 and 1984. During this period, the following acute and chronic toxicity tests were conducted.

Acute

rainbow trout lethality daphnid lethality amphipod lethality algae photosynthetic inhibition

Chronic

algae growth inhibition
daphnid reproduction inhibition
amphipod growth inhibition
fish embryo hatchability
rainbow trout growth inhibition
rainbow trout bioconcentration
fish avoidance behaviour
fish tainting
flagfish lifecycle inhibition

The acute lethality tests were conducted on a more frequent basis than the chronic tests for reasons of cost-efficiency.

A combined biomonitoring/bioeffects monitoring program was conducted during the same period. The program included bottom-dwelling invertebrate abundance and diversity studies, spottail shiner contaminant bioconcentration monitoring and freshwater clam bioaccumulation.

The results of this four year program can be summarized as follows:

- treated final wastewater chemistry and acute/chronic toxicity test results indicated that the final treated wastewater discharged to Centre Creek was innocuous.
- the Long Point Bay water chemistry and biological monitoring surveys indicated that the Stelco discharge had no measurable adverse effect on the immediate receiving water quality or aquatic life.

- Stelco met all conditions of their Certificate of Approval and received approval from MOE to continue discharging their treated wastewater to Lake Erie via Centre Creek.
- the multi–million dollar cost of constructing and installing a lengthy submerged outfall for wastewater discharge was avoided by Stelco.

My next example comes from the pulp and paper industry. I'll be briefly outlining an effluent toxicity reduction program that has been underway at Kimberly Clark's bleached kraft pulp operations in Terrace Bay, Ontario, since 1982. This pulping operation is a combination of old and new. The original mill was built in 1948 and then expanded in 1978 to triple production. The liquid effluent discharged from the mill receives primary treatment only. Past evaluations of Kimberly Clark's final mill effluent indicated that the mill was discharging unacceptable levels of suspended solids and BOD5. Samples of the final mill effluent evaluated for acute lethality to rainbow trout during 1981 and 1982, produced LC50 values which ranged between 4 and 15% v/v.

The question the company had to resolve was what was the most cost–effective approach to reducing chemical losses and acute toxicity in their final mill effluent discharge to allow them to meet the requirements of their pollution abatement Control Order (e.g., TSS 7.0 ADt/d, BOD5 30 kg/ADt/d, acute toxicity LC50 > 100% v/v) which had been negotiated with the Ontario MOE in early 1982. Kimberly Clark management chose an in–mill control approach which included an on–site monitoring program to quantify the in–mill sources of effluent acute toxicity/chemical losses and a mill process engineering review.

During the summer of 1983, the Ontario MOE conducted an in–situ toxicity and biomonitoring program in Jackfish Bay, Lake Superior near the location where Kimberly Clark's effluent discharges to the lake. The MOE program included caged rainbow trout exposures to establish whether or not there was potential acute lethality to fish exposed to diluted mill effluent in Jackfish Bay. Water samples from the bay and tissue from surviving caged–exposed rainbow trout were analyzed for resin acids and chlorophenols.

The MOE monitoring program confirmed that Kimberly Clark's effluent had a definite effect on Jackfish Bay biota. Acute lethality of caged rainbow trout was observed up to 1 km away from the point of effluent discharge to Jackfish Bay. As well, significant bioconcentration of chlorophenols was detected in surviving caged rainbow trout up to a distance of 1.5 km from the point of effluent discharge.

Kimberly Clark hired a consulting firm to conduct the in–mill sewer monitoring program and the process engineering review. During a four month period in 1983, seven mill sewer system surveys were conducted to identify and quantify the most important sources of fibre, energy and saltcake (i.e., pulping chemical) loss and acute toxicity contribution by mill department and/or process. Based on the results of the sewer monitoring survey and the engineering review, the consultant's process engineers recommended nine in–mill process changes to reduce levels FTSS, BOD5 and acute lethality in the final mill effluent. Kimberly Clark management accepted the recommendation program in 1986 to improve the quality of the final effluent. As of December 1987, all nine mill process modifications have been implemented and final mill effluent quality has improved to a point where the TSS and BOD5 limits are being consistently met. The acute lethality of the final effluent has been reduced by 40 to 60%. However, it is my personal opinion that installation of an out–plant secondary treatment system will be required before the mill can consistently meet MOE's acute lethality requirement of a LC50 > 100% v/v.

My last example comes from the natural gas processing industry. I'll be summarizing the results to–date of a Canadian Petroleum Association/Environment Canada program examining the historical waste sludge problem at gas plants. There are over 400 sweet or sour gas processing plants in Western Canada. Each plant has on–site waste disposal pits or ponds with sludge accumulations varying from 1 to 20 m in depth. The purpose of the joint research program was to develop and validate a procedure for determining the chemical characteristics and environmental significance of gas plant sludges. In the two field validation studies conducted, a total of 6 sludges collected from 4 Alberta sour gas plants have been analyzed using a tiered testing approach which involved organic/inorganic analyses and acute toxicity/genotoxicity assessment of whole sludge and associated interstitial liquids. The biological tests were chosen to measure the following effects:

Whole Sludge

earthworm lethality

seed germination inhibition

Interstitial Liquids

daphnid lethality
green algae growth inhibition

bacteria light inhibition (Microtox)
bacterial enzyme inhibition (Chromotest)
bacterial genotoxicity response

(SOS–Chromotest)

The results indicated that the battery of toxicity tests conducted on the whole sludge and interstitial liquids could be used as a cost–effective sludge pre–screening step to avoid the cost of detailed organic analyses. The other main conclusion of the research was that the degree of hazard presented by the waste sludges could not be determined by chemistry alone. A combination of chemical measurement and biological effect information is required to properly assess the hazard presented by different gas plant sludges.

In conclusion, I have two thoughts I'd like to leave with you:

- laboratory toxicity testing and ambient bio-effects monitoring both have a role to play in any wastewater or waste residue abatement program, and
- biological testing should be used with chemistry in the characterization, monitoring and regulation of wastewaters, waste residues/solids and toxic chemicals.

QUESTIONS TO PETER WELLS AND RICK SCROGGINS

Q. Peter Chapman

I whole-heartedly agree with the idea of having chemistry and biology together in order to determine toxicity. However, I do caution you, Rick, on one matter – you had bioaccumulation under bioffects and bioaccumulation is a phenomenon not an effect. Also, in Peter's talk, Peter said specifically and, Rick, you intimated that biological techniques do not necessarily stand on their own. To the contrary, I think that in many cases they do and they have to because we can't measure everything that is out there. As you showed in your own example, there was a case where you measured for expected chemicals and found nothing. You went back and remeasured and found other chemicals which may or may not have been the chemical that caused the observed effects; it may have been something that was covarying that chemical. So in many cases biological techniques can and will stand on their own and they should not be judged solely in terms of whether they match with the chemicals measured.

A. Rick Scroggins

No, you're right. It is not clear cut. But as one biologist working with many engineers, it is important to exploit both biological and chemical tests.

Q. Ray Effer, Ontario Hydro

One pollutant that the last two speakers did not mention which might prove a very useful basis for much of our discussion is heat. Heat is classified as a pollutant under the Clean Water Act and the number of research papers that are being published on heat as a pollutant would dwarf most of the research on the chemicals mentioned by the speakers. I think that it would be a very useful field to use as an example of the complexity of dealing with one specific pollutant. If you look at the historical work by Fred Fry, you will realize that just looking at one variable introduces an incredibly complex system in terms of species, life histories of species, pH disassociation constants, etc. I'm just wondering whether once we zero in on any one particular pollutant whether we might find ourselves in that incredibly complex minefield which many of the researchers on heat found themselves 15 to 20 years ago. It doesn't seem to be a very fashionable pollutant these days, but it still lives with us; our Darlington Generating Station is putting in an offshore diffuser to the tune of well over a $100,000,000, in order to offset the thermal effects of heat on developing white fish eggs.

A. Rick Scroggins

I agree that this area of research is important. I know a lot about it myself because I worked for Ontario Hydro Research at Kipling before I started into consulting, so I'm familiar with what you're talking about.

Q. My question is on the legal enforcement of biomonitoring tests. How effective are chronic effects tests, will they turn up in the code in terms of prosecution of control orders without any chemical analysis?

A. Rick Scroggins

There are a battery of tests that are being used right now in regulation in the United States by the E.P.A. e.g., the 7-day Ceriodaphnia test, the fathead minnow test, larval growth inhibition tests, etc. I think that Canada is behind in this area.

Q.S. Ramamoorthy, Alberta Department of the Environment

We have it in the regulatory permits, but no judge will always buy that. An expert will say that there is variation between species of fish and all our efforts are shot down. When you go for a chemical analysis, and record 30 ppm chloroform and the regulation says 20 ppm is acceptable, this cannot be argued. How do you compare the chemical effectiveness of a chemical analysis compared to chronic testing in enforcement?

A. Rick Scroggins

Actually I don't even have the full understanding of what the regulatory person needs for making that judgement or when you use one over the other. I believe that chronic tests can be as effective or more effective than a chemical limit and more defensible.

A. Peter Wells

Sublethal toxicity data have been presented in court a number of times in Canada under the Fisheries Act and in that sort of situation you rely upon very credible expert testimony to state a judgement as to whether the material being discharged is likely to have, according to the Fisheries Act, a deleterious effect on fish or fish populations and when its given in that perspective, and the judge understands, it can be quite effective in presecutions.

Q. Ed Hanna, J.E. Hanna & Associates Ltd.

I think that the safe position is to take both chemical and biological data. If you look at the total costs involved in compliance monitoring, while industry may gripe about it being very high, we've just done a survey of what it costs to dispose of hazardous waste. Disposal is much more expensive than compliance monitoring and it's less than 1% of the total operating costs. If you want to take the safe route, there's not much question about chemical or biological. The only problem that I have with that is that sometimes biological data gets the back seat. I think the solution to the problem is the development of good, standardized tests that are ecologically meaningful.

A. Rick Scroggins

Environment Canada has launched into a four-year program to write and validate National Protocols for Toxicity Tests.

BIOLOGY AND THE MINISTRY OF THE ENVIRONMENT

by

James N. Bishop, Director
Water Resources Branch

Ontario Ministry of the Environment

Biology in a regulatory framework reflects a natural synthesis in the development of effec tive environmental protection measures. Increasing awareness of the importance of environmental health has led to the strengthening of both the role of biology and the tightening of regulatory tools to achieve environmental protection goals. You have only to read April's news clippings to see how the pulp and paper sector, for one, has realized this.

The following is an outline of the continuing and growing importance of biological considerations in the Ministry of the Environment, which is moving progressively toward a more regulated approach to protecting Ontario's environment. In particular, I'd like to present an overview of our MISA program and indicate the role biology plays in it.

Biology plays a major role in numerous aspects of the policy formulation, program development, and program implementation activities of the Ontario Ministry of the Environment. It plays a key role in the aquatic programs conducted by the Water Resources Branch. I have been asked to stress MOE's MISA program, but before I do, I'd like to mention areas in the Ministry and in my Branch where biology plays a major role. As you will see, this role is being increasingly applied in a regulatory context as the Ministry moves, according to the Minister's commitment, towards tougher environmental protection actions.

First of all, biology plays a major role in all of the Ministry's regional operations. Each of the six regions has Regional Biologists, and on the atmospheric side of regional life, the phytotoxicologist plies his particular form of biology.

Within Water Resources Branch, biology plays a role in all sections. The Water Quality Office consists of four sections that rely to a major extent on biological sciences, including work on the Great Lakes, Limnology and Inland Lakes, and River Systems. In particular, the section called Aquatic Biology, as its name would indicate, consists exclusively of working biologists.

These biologists are involved in a wide range of activities as follows: Aquatic Toxicity (lab testing of biota, effluent toxicity, lethality, growth); Aquatic Plants (phosphorus control, algae responses); Biohazards (mutagenicity, genotoxicity); and Bioassessment (sportfish and young-of-the-year testing, sediments).

In other programs, biology plays an essential but not exclusive role, for example, in the drinking water program, and particularly in the Ministry's major waterway cleanup program, MISA, the Municipal-Industrial Strategy for Abatement. MISA represents the latest regulatory milestone in environmental protection, and before I go on to talk about it, I'd like to set it in the context of other existing regulatory tools that are complementary to MISA. These also rely to a considerable extent on biological considerations and they also are becoming progressively stronger.

Currently, every discharger into surface water is required to have a Certificate of Approval from the Ministry of the Environment issued under the authority of the Regional Director or Approvals Branch Director. These certificates specify environmental protection requirements with which the discharger must comply or face prosecution by the Ministry. These certificates can and often do include explicit measures expressed as effluent loading limits based on environmental protection, that is, the health of the aquatic community affected. These are also based on the Ministry's Blue Book principles and policies.

In the case of a serious environmental problem where a particular discharger can be identified as the source of the problem, a Control Order will be placed on that discharger. This is a finite document; that is, it specifies measures required to be taken by the discharger by a certain time. In most cases, the problem is one of biological impacts, for example, a fish kill.

Another avenue for regulated controls is litigation, usually prosecutions for various kinds of violations like spills or other kinds of non-compliance with regulated requirements, as well as appeals by dischargers against Control Orders or Certificates of Approval.

Litigation involves two major issues. The court has to determine the discharger's "potential to pollute", that is, harm the environment, in order to establish guilt. These impacts are usually biological impacts on receiving waters or impacts on a water supply. The subsequent issue to be determined is the extent of the impacts, which determines the level of penalty. This can be judged by the zone of the biological impacts, causing death or injury to the aquatic community.

In recent months, there has been a greater tendency to conduct biologically-based laboratory tests, for example, on impacts on aquatic life of material spilled into waterways, and to observe effects. Those conducting the tests then testify to those effects in court. This has become a very useful regulatory tool, since the level of fines has recently become significantly higher as a result of Mr. Bradley's recent actions, and therefore legal action has a greater impact on dischargers. They in turn are targeting more resources to legal defence and to retaining their own environmental specialists.

This brings us to MISA. MISA is a regulatory program that will control and reduce the amount and concentration of toxic contaminants in all municipal and industrial effluents discharged to surface waters. MISA's long-term goal is consistent with that of the Canada-U.S. Water Quality Agreement for the Great Lakes — virtual elimination of toxic discharges into the Great Lakes, and in MISA's case, to all of Ontario's waterways.

For each of the major industrial sectors and the municipal sector, two regulations will be developed. As the MISA program evolved, the regulatory track was complemented by water quality studies. Initially, dischargers will be subject to an effluent monitoring regulation which will require them to identify and measure concentrations and amounts of toxic contaminants in their effluents. This self-monitoring program will be strictly audited by the Ministry.

The data collected and assessed as part of the monitoring phase will be used to develop an abatement or effluent limits regulation that will specify allowable concentrations as well as amounts or loadings of toxic pollutants for each discharger. This too will be done on a sector-by-sector basis. The limits will be based on the Best Available Technology Economically Achievable (BATEA).

We will arrive at effluent limits by going through a process of consultation. Ontario considers dialogue between the regulator and the regulated to be essential to a successful program.

As you see, MISA is essentially a technology-based initiative, with considerable input from the industrial associations, and from the Federal and provincial government. Currently, there are active Joint Technical Committees for 9 industrial sectors and the municipal sector, made up of sector representatives from MOE and Environment Canada. These committees are developing monitoring regulations, using the most up-to-date engineering and scientific information, to ensure the technical soundness of the regulations, without which they would have no credibility for anyone — industry, the scientific and technical community, and the public alike. Voluntary pre-regulation monitoring has been undertaken by some sectors to date, and the first monitoring regulation — for the petroleum refining industry — is in the process of promulgation.

Complementary to the technology-based activities in MISA are water quality studies which are fundamental to developing regulated requirements. Let's first examine the role of biology in the monitoring regulations. Monitoring regulations include bioassays, with a view to the potential development and inclusion of toxicity limits in effluent limits regulations. Currently, toxicity tests using rainbow trout and daphnia are incorporated into the monitoring regulations. The rainbow trout 96-hour LC50 test has been in use for close to two decades; the daphnia LC50 test has also been available for some time but not applied until now. It is important for continuing technique development that data from these tests be collected and evaluated.

This is a fertile area of development worldwide, and MOE is a keen participant in this work. Our aim is to develop bioassessment techniques that are reliable, reproducible, understandable to the public, based on technology that contractors can readily use, and leading to environmentally meaningful endpoints.

In related MISA work, biology is essential in developing the Effluent Monitoring Priority Pollutants List for Ontario on which monitoring requirements will be based. It is essential also in the preparation of a listing/delisting mechanism for altering the kinds of monitoring and controls for parameters required for a particular sector.

The Water Quality aspect of MISA has been an integral part of the conceptual development of the program. This aspect consists of biological impacts assessment, site-specific water quality studies, pilot site studies involving industrial/municipal discharges into surface waters, and water quality policy revisions. However, scheduling concerns have required that these facets of the MISA program be delayed by about three years.

I'd like to identify some of the problems with the biological aspects of the regulations which may contribute to this delay. They are a combination of scientific and perceptual difficulties. First, perceptual factors. Water quality "standards" are perceived to be uncertain by government rulemakers and industry alike. This should not be surprising, since water quality work is based on scientific experimentation, and as all of us know, scientific outcomes are often unpredictable and require a great deal of resources and effort and verification. And all of that takes time, which leads to the next problem. Water quality studies are seen as activities delaying the delivery of regulations by the provincial government. Moreover, biological aspects of regulatory tools are not universally accepted by industry. Some sectors question the need for regulations at all, but even the more advanced industrial thinkers — those who recognize that they must bear some environmental responsibility — have difficulty relating biological standards to production or effluent standards.

Now we get into some of the more pragmatic problems. First, biological studies and biological components of regulation are seen as very costly, although they probably will be less expensive than blanket chemical coverage. However, there are real problems with ensuring an adequate provincial testing and analytical capability, both government and private capability. This leads to questions of certification of labs and the complexities of QA/QC considerations. The mechanism of listing-delisting of compounds from lists like Ontario's Effluent Monitoring Priority Pollutants List (EMPPL) is not clear. As you can imagine, this will be the subject of vigorous debate at the Joint Technical Committees as well as presenting a real scientific challenge. Finally, the translation of biological tests into actual standards or effluent limits is another thorny political, perceptual and scientific challenge.

These concerns arose despite the fact that very significant staff and resource increases have been added to MOE's budget base. They arose primarily because of concerns that the delivery of the monitoring regulations and effluent limits regulations would be delayed by including the site-specific biological component.

If I could reiterate the process of industry-government dialogue, I think most of you will agree that while such a process is necessary, fair and democratic, and leads to full discussion of all viewpoints, it is very, very time-consuming. So time-consuming, in fact, that the delivery of the first regulation, the Ontario Petroleum Association's (OPA) monitoring regulation, is late by several months. And this was the sector that had a large data base, was tractable, positive and progressive, and was the model for the other sectors.

Because issues like detection limits, inclusion of daphnia testing as well as rainbow trout testing, and other matters require the give and take of the Joint Technical Committee (JTC), as well as involvement of the MISA Advisory Committee (MAC), and because we are committed to the development of technically sound, high quality, industrial-strength regulations, we have taken the time needed to properly form our agreements — with industry, with MAC, and with our provincial politicians. As we now move into the other monitoring regulations, we will retain the biological aspect of monitoring and will benefit from the debates of the past year with the OPA and MAC.

However, as we move into the compliance, or effluent limits regulations, the inclusion of site-specific water quality-based limits would, without question, substantially delay the regulation promulgation process. For this reason, the Water Quality track and Technology track will not be developed simultaneously. Rather, we will continue to monitor the progress of the U.S. EPA and our Federal colleagues in developing water quality-based regulations. As well, we are in constant contact with progressive U.S. State agencies like NYDEC, who have developed specific ambient criteria for toxic substances to be applied to site-specific water quality-based effluent limits.

On the other hand, the litigation that the U.S. states face whenever such limits are promulgated is daunting, and was a primary reason for Ontario's approach of pre-regulation consultation and evolution of consensus in both monitoring and compliance regulation development.

Nevertheless, biologically-based development work is going on. A key part of the MISA water quality activities are pilot site studies at 6 locations around the province to assess environmental conditions and to develop and evaluate bioassessment techniques. The locations themselves were selected to represent various kinds of receiving waters (lakes, rivers) and various kinds of industrial or municipal inputs (large and small sewage treatment plants, pulp and paper, iron and steel, etc.).

The development of new bioassessment techniques is only one of the purposes of pilot site studies. It is expected that procedure manuals can be developed for use by dischargers or their contractors for application of these techniques to various local conditions. Eventually, water quality-based limits can be set at each site as examples of what will be required to meet water quality protection goals. These test-site limits can then be evaluated against technology-based effluent limits to determine if more stringent controls are necessary to provide aquatic protection beyond that specified in BATEA limits.

The timing for introducing water quality-based limits has not yet been established, but will be consistent with MISA's goal of virtual elimination of toxic discharges into Ontario waterways. It will probably be phased in on the basis of cyclical reviews of technological advances related to BATEA (e.g., 5 years).

I can't tell you all this about MISA without drawing attention to the fact that at every step of the way and in all aspects of the program, Environment Canada has been a valued partner in MISA since the beginning of the program. They have contributed staff resources, expertise, and have worked with us on a range of joint projects and studies on such things as water quality assessments, effluent toxicity and evaluation of specific treatment technologies. We recognize that their involvement adds an important national and international perspective to MISA. They have helped us to encourage other provinces to understand MISA's principles with the long-term objective that programs to control the release of toxic chemicals will be undertaken in other provincial jurisdictions. To summarize, we really appreciate their co-operative efforts in making MISA a workable reality.

As you see from what I've said today, the development of MISA to date has had its share of successes, however modest, and pitfalls and difficulties, however daunting and hard to resolve. What keeps the process going, often doggedly, is our own conviction that we are on the right road, doing the right thing. MISA represents a great stride in environmental protection in Ontario. If we continue to adhere to our key principles of technical soundness and consensual development, I have every expectation that progress will continue steadily towards MISA's goal of virtually eliminating toxic discharges to Ontario's waterways.

BIOLOGICAL ASSESSMENT FOR WATER POLLUTION CONTROL*

**Full text appears in: Ontario Waste Management Conference, June 1988*

by

Gary F. Westlake and John G. Ralston
Aquatic Biology Section
Water Resources Branch
Ontario Ministry of the Environment
P.O. Box 213, Rexdale, Ontario

INTRODUCTION

Toxicity testing is a basic component of new monitoring regulations currently being developed in Ontario as part of the MISA (Municipal Industrial Strategy for Abatement) program (MOE, 1986). While it is premature to estimate the extent that biologically based limits will be incorporated into subsequent effluent limits, it is reasonable to expect that they will be important. It would be illogical to try to eliminate toxic substances from industrial and municipal effluents without assessing the whole effluent for toxic effects.

EQUITABLE WATER POLLUTION CONTROL

In order to accomplish this regulatory initiative, the ministry needs to establish biological as well as chemical limits on sources. On the biological side, an environmentally relevant measure of quality is required that is realistic for the available treatment technology of a broad spectrum of discharge types.

Setting Goals that Can be Achieved for all Sources

The Ontario Ministry of the Environment has a long history of monitoring industrial discharges for acute lethality to fish. Within the past three years monitoring for acute lethality to Daphnia magna has been routinely added. From this body of information, an overview can be obtained on the quality of effluents in the province. While the data are biased because sources were sampled irregularly for a variety of purposes, they clearly show that there are a significant number of effluents in Ontario that kill fish. Even though the sampling was not evenly distributed, the results indicate, in Ontario, that we have some distance to go before sublethal procedures will have a significant advantage for monitoring and control purposes.

In the light of this current state of discharge quality, it is unrealistic to try to remove all sublethal effects at the point of release of industrial wastes. It may, however, be possible to remove acute lethal effects for all sources in the province. It may also be possible to eliminate widespread sublethal and chronic effects through restricting them to a small initial mixing area downstream of discharges. Most measurable sublethal effects are observed at concentrations relatively close to those causing lethality. Therefore, except for receiving environments with limited flows, controlling acute lethality will also control most, if not all, sublethal impacts, with the exception of the bioaccumulation of persistent toxic substances.

Do the Same Standards Apply to Continuous Discharges as to Accidental Spills?

It is easy to concentrate pollution control efforts on the small pollution sources because these are easier to study and to prosecute. If the criteria for success is the number of successful court cases, then this is an effective strategy. However, if the criteria is the extent of environmental improvement, then concentrating on the small and accidental discharger is ineffective.

THE POWER OF BIOLOGICAL MONITORING

Biological tests are powerful instruments for pollution monitoring and control. They measure potential, environmentally significant effects of complex mixtures directly.

They are also cost effective, rapid and simple to perform. Considering them only as a group of analyses among the many that can be used to characterize an effluent is absurd. Their role is indispensable. Not only are biological tests used to assess effluent quality directly, but also indirectly in Ontario through surface Water Quality Objectives and Guidelines.

Biological vs. Chemical Monitoring

Most industrial effluents are complex mixtures of substances even in cases where one or two substances predominate. The Ministry of the Environment has prepared a list of substances for characterizing industrial effluents. This list, called the Effluent Monitoring Priority Pollutants List, is derived partly from documented occurrences of various substances in industrial and municipal effluents. Even though not all members of an industrial group will necessarily contain all substances from that group, the list is formidable. Clearly, since this list is restricted to those substances that now can be measured by available technology, and is restricted to those that have so far been looked for, it is incomplete.

While it is essential that effluents be characterized on the basis of at least some key chemical substances, the task of interpretation should not be underestimated. The potential environmental impact of these substances is evaluated by reference to toxicological literature. For some substances, the literature is scanty and for others, it is extensive. For very few substances, do we have information on combined effects of mixtures. Interpreting the results of analyses from concentrations of sometimes hundreds of substances in a given sample may require super-human capabilities.

The cost of doing the analyses is another factor to consider. Two people can realistically perform about 250 static trout tests or up to 500 Daphnia tests per year. The cost of trout tests generally range between $400 and $800 and Daphnia tests between $250 and $500. Chemical analyses can cost considerably more. The protocols insist that biological tests are completed within five days. Commonly, chemical characterization takes longer. Clearly biological testing of effluents has a place in testing strategies and often offers distinct advantages.

Water Quality Objectives, Guidelines, Criteria, etc.

In characterising effluents chemically, it is often assumed that there exists enough knowledge about the effects of individual substances to make useful interpretations of the data. The Ministry is in the process of accelerating the development of Provincial Water Quality Objectives and Guidelines to support the MISA Program. Many of the substances on the Effluent Monitoring Priority Pollutant List do not yet have enough toxicological data in the literature to develop Objectives or to make water quality management decisions solely on the basis of chemical characterization of whole effluents. It is possible, however, to monitor for biological effects on whole effluents and use the chemical characterization to interpret these effects. It is common for aquatic toxicity testing laboratories to review chemical data on a sample and suggest in their reports, potential causes for observed toxicity based on their knowledge of the literature.

TOXICITY AND WATER USE

It is a common view that requirements for toxicity reduction in effluents is in conflict with requirements for water conservation. Even in Canada where water is in abundance, we should be able to expect both. If we deal in "water use credits" for effluents of hundreds of thousand of cubic meters a day, how can we, in conscience, control small spills? The Ministry is phasing out the use of water conservation credcits over the next few years. The exception to this is for substances that bioaccumulate where loading estimates are useful.

Bioaccumulation

It is very difficult to simulate, in the laboratory, environmental conditions that permit a persistent substance to bioaccumulate in aquatic organisms. Neither acute lethal tests nor other readily available procedures do much to assess the potential for bioaccumulation from effluents. Similarly, although perhaps less obvious, is the fact that effect levels are frequently unknown because the literature on the mechanisms of bioaccumulation are limited and contradictory. There is a great need for controlled laboratory experimentation involving the uptake of substances in aquatic organisms.

The best information on the bioaccumulation of substances is from field monitoring of tissue concentrations and controlled field exposures involving caged organisms. The Ministry is involved with a number of programs for evaluating bioaccumulation in the field. Tissues analyses from sport fish over the past number of years have shown levels of contamination in the province and long term trends. Similarly, tissue levels in forage fish have helped to identify potential sources. Exposing aquatic organisms in cages to effluents in the field has also been used to assess the impacts of point sources.

For control of bioaccumulating substances, it is necessary to monitor and control the loading levels from point sources. It is not necessarily possible to directly measure the fate of substances through the ecosystem. Hydrophobic substances, for example, are so readily accumulated by tissues that aquatic organisms can become contaminated even where the water column concentration is so low that it cannot be measured.

Acute and Chronic Effects

Acute effects, both lethal and sublethal are concentration–based. It does not make sense to manage these impacts through controls on loading. Three things need to be controlled, and they can be controlled separately. First, limit water use per unit of production. Secondly, control lethal and sublethal acute impacts by end–of–pipe and edge–of–mixing zone limits. Thirdly, control the most persistent bioaccumulating and chronically acting substances through chemically monitoring and loading based limits, making sure to verify improvements with field monitoring.

PRACTICAL CONSIDERATIONS

The use of procedures from the toxicological literature for regulation has to be balanced against practical considerations of resource availability and relevance to present water quality. It is often the simplest of techniques that is most effective as long as the most possible benefit is obtained from the information that we do require.

The Power of Keeping it Simple

Being aware of existing discharge quality

If the present quality of discharges in the province was such that samples from them did not kill fish, then biological testing would have to involve more sensitive tests to get usable results. However, this is currently not the case, and more sensitive tests would not be efficient for improving the environment resulting from the situations encountered today.

Appropriate tests for specific needs

Less than an order of magnitude similarity between acute lethal results and sublethal or chronic values is common. Moreover, for an effluent that is acutely lethal, the variability of the discharge is greater than the difference between acute and chronic information. Combining this with the relative cost of performing the two procedures results in the inescapable conclusion that for effluents of this quality, acute lethal tests are the most efficient monitoring tool. For effluents of better quality, the situation changes, because a point estimate of acute lethality may not be possible.

Sometimes we leave the impression that we are searching for the ideal toxicity test and, as soon as we find it, we will be able to drop all the others. A comparison of trout acute lethality test results with acute lethality results to Daphnia on the same samples shows different sensitivities of the two animals to different effluents, suggesting that the use of both of these tests is much more valuable than the use of one only.

The Power of making the Most of the Data You Get

Who needs to understand biological tests?

A large part of the working lives of aquatic toxicologists in Canada has been spent in education of people directly working in the field of water pollution control on basic concepts of toxicity such as LC50, acute, chronic, etc. Water resource managers must make a point of understanding the procedures and implications of biological tests.

The need for published test protocols

It is difficult if not impossible to have biological tests done by many people without establishing common methods in published protocols. The Ministry has for some time been using the same published protocol for static acute lethality test to trout and has recently published an official test protocol for Daphnia magna acute lethality.

The management of data quality

Obviously, with the limited existing resources in aquatic toxicology in the federal and provincial laboratories, it is necessary to count on self testing by industry to adequately monitor effluents. Most, if not all, of the capacity should then be applied to an audit program. Even then, the audit program has to be a simple one to be evenly and fairly spread across all discharges. The Ministry's audit is expected to be made up of selected split samples with the industry or its contractors. We have rejected the use of lab accreditation since the quality of the results can slip before the ink is dry on the ceritificates. We also rejected the global use of reference toxicants, since these are not adequate for dealing with the great variety of effluent mixtures.

The management of biological data

Toxicity data has a different structure than most chemical characterization data. Simply reporting the results as LC50s is inadequate. In anticipation of receiving large amounts of toxicity data, the Ministry has developed a data management program called TOXDATA. This program permits the detailed and summary reporting of aquatic toxicity data.

REFERENCES

Ministry of the Environment, Ontario. 1986. Municipal–Industrial Strategy for Abatement (MISA): A Policy and Program Statement of the Controlling Municipal and Industrial Discharges into Surface Waters. MOE, Toronto.

Ministry of the Environment, Ontario. 1987. Report on the 1986 Industrial Direct Discharges in Ontario. MOE, Toronto.

Ministry of the Environment, Ontario (in press). Effluent Monitoring Priority Pollutants List. MOE, Toronto.

QUESTIONS TO JIM BISHOP AND GARY WESTLAKE

Q. Martin Samoiloff

I have both a comment and then a question. I'm delighted to see something that is based on best available technology. I'm intrigued with the fact that the Ontario and Federal experts look within their own facilities rather than look to Europe and the United States, and ignore the fact that there are other people in Canada who may be involved in the process and may contribute to the technology. My question is – I have heard comments from people in industry saying that MISA, if it's every fully implemented, will be too costly. Would you care to comment on that?

A. Jim Bishop

We are probably guilty of not looking in our own backyard and we will take steps to remedy it. We have presented the basic thrust of the MISA program in other areas of Canada e.g., Maritimes, B.C., Alberta, Quebec, etc., and where we are able to get information that would be usable to us either in the municipal or the industrial abatement side, we certainly will take the advice. As far as the cost implication, whenever any form of government anywhere in the world says that they're going to implement a new regulation, I would be surprised if industry did not say that it's going to cost too much. It is not going to cost too much that it cannot be done. The other thing to bear in mind is that in other jurisdictions where they have had terrible pollution–related problems, e.g., salmon streams in Oregon prior to the Clean Water Act in the U.S.A, it was said that it was going to break the industry. Well, the fact is that they now have 22 streams that have trout reproducing and they didn't lose a mill. Similarly, the recently released Pulp & Paper Expert Committee Report indicated that right now that sector would be able to put in close to Best Available Technology to allow them to pass most of the things that we've been concerned about.

Q. Martin Samoiloff

To what degree is the private consulting sector outside of individual provinces allowed to compete within that province for business?

A. Jim Bishop

We do have contracts and programs related to MISA that go from Quebec to British Columbia.

LEGISLATIVE FRAMEWORK/PEST CONTROL PRODUCTS ACT AND REGULATIONS*

** paper presented by F.A. Yan Chen*

by

Dr. J.E. Hollebone, A/Director
Issues, Planning and Priorities Division
Pesticides Directorate
Agriculture Canada
Ottawa, Ontario
K1A 0C6

Pesticides are regulated in Canada under the Pest Control Products Act and Regulations. The Act and Regulations have served as models for subsequent legislation including, in part, the new Canadian Environmental Protection Act. The essential principles of the Act require a presale assessment to ensure safety, merit, and value before use. Scientific studies are reviewed by experts in advising federal depart ments to provide risk and benefit assessments, which are weighed in a decision making process, and communicated to stakeholders. Most pesticides pass through 4 regulatory phases, Research Permit for Field Release, Temporary Registration, Full Registration and Re-evaluation, which are described in detail. The registration process has evolved in response to changing technology and analytical advances. Current challenges lie in developing guidelines to regulate the products and processes of biotechnology, microbial and biopest control agents, aquatic toxicology testing requirements and to reduce potential pesticide contamination of groundwater. The relationship of the PCP Act and Regulations to the new Canadian Environmental Protection Act is discussed.

The three major cornerstones of the Act require that a presale assessment ensure that pesticides registered for use meet criteria of 'safety, merit and value'. This provides for regulations, allowing the Minister of Agriculture to require results of scientific studies to allow assessment using these criteria. Thus, in Canada, pesticides have been registered on the philosophy of "guilty until proven innocent". The regulations have provided for the development of regulatory guidelines outlining requirements for extensive testing to allow regulators to assess potential risks and benefits associated with use, and make appropriate regulatory decisions.

Data Requirements for Registration

In the early 50's, a pesticide required acute toxicology testing and some performance and residue data, but virtually none of the detailed studies which are prerequisites to the intensive risk assessments of possible chronic effects and environmental assessments required today. By 1980, the data to support registration had evolved into a complex series of testing requirements involving studies in chemistry, toxicology, environmental chemistry and fate, environmental toxicology and performance data worth about 7 million dollars. Ten percent of the studies are required to be done in Canada, the rest are studies, mostly toxicology, which can also be used for registration in most countries of the world. The Canadian studies are required to provide data specific to Canadian agronomic, geographic and climatic conditions and are mainly performance, residue and environmental studies.

In setting data requirements, regulators must balance what is nice to know and what is needed to be able to estimate risks and benefits of a pesticide. It is not enough to "feel" or "desire" a new study. One must be aware that too stringent requirements "up the ante" and the higher this is, the less attractive the marketplace will appear and fewer the products submitted for registration. Crop production and our competitiveness, at least internationally for major crops and commodities, is dependent upon availability of pesticides. While the Department has a long term strategy to reduce chemical dependency by better use practices, and by reduced applications and biological pesticides, chemicals are still needed in the immediate term. On the other hand, data requirements must also be extensive enough to allow adequate testing to be able to make valid and realistic risk assessments so that only environmentally acceptable and safe pesticides are available. The balance of regulatory requirements is difficult to attain, and must be somewhere between the two polarizations.

Risk Benefits Assessment

Canadian, unlike American legislation, is silent on the process of risk benefit assessment. There is some pressure to clearly enshrine this concept in regulations. The Act allows the Minister of Agriculture to take regulatory action if he has indication to believe unreasonable risk of harm to the environment or human health. In practice, risk benefit assessment has been an integral component, if unproclaimed, of regulatory decision making for many years.

Registration of pesticides is essentially consultative in nature. Assessments of risk are provided by Departments of

Health (human safety – risk through food consumed, and risk through exposure either via application or via accidental or secondary exposure), Environment (risk to physical environment and nontarget organisms) and Fisheries and Oceans (risk to fish or fish habitat). These are assessments based on review of scientific studies, and are science–driven.

Benefit assessments (e.g., yields, cost, improved quality of food) are made in Agriculture and are also scientific judgements made on scientific and economic studies. Considerable effort has gone into improving the benefits assessment process, partly as a result of the Alachlor Review Board Report recommendations.

Risk Management

The final steps in the process are risk management and risk communication. In the former, the risks are assessed against benefits and a regulatory decision developed. Usually at this stage there is much discussion/consultation back and forth between advisers, industry and experts whose opinions are sought. At this point other factors, political, socio–economic may play a role in the final decision–making. The final step is publication and communication of the regulatory decision, giving the scientific rationales and considerations weighed in the decision–making process. In recent years much effort has gone into publishing the regulatory position. The risk assessments are written and published by the advising departments while Agriculture, as the regulatory authority, provides the decision–making rationale. These are communicated as Discussion or Decision documents, to a wide audience.

Weight–of–Evidence Approach to Decision–making

The recent Alachlor Review Board supports our current practice of a "weight of evidence" approach in regulatory decision–making. As part of ongoing improvements, we are asking advising Departments to define risks more clearly, to indicate clearly the methodology used to assess the identified risks, and to clearly communicate significance of the risks. This increased accountability is essential to modern decision–making.

On our side, Agriculture Canada is also improving quantification of benefits. A first detailed benefits document has just been produced on 2,4–D and phenoxy herbicides, which will also serve as a model for future benefit assessments. Where possible, the decision–making process will also be more quantitative rather than qualitative.

Regulatory Options

The Canadian regulatory process provides a series of options, designed to accommodate the wide range of circumstances encountered in practical situations. The Canadian approach is similar to the system used in the U.S. and other developed countries. It is a stepped process involving several stages: Research Permits, Temporary Registration, Full Registration and Re–evaluation.

> Section 5 of the PCP Regulations allows opportunity for necessary research to proceed, while maintaining an appropriate degree of regulatory control. Section 13 establishes "registration" as the principal regulatory vehicle. Section 17 provides for registration, for a period not exceeding one year, with associated terms and conditions. This provision is directed to situations where:
>
> (a) The applicant agrees to endeavour to produce additional scientific or technical information.
>
> (b) It is necessary to provide emergency control of pest infestations.
>
> Section 19 carries authority to re–evaluate products. Provision for suspension or cancellation of registration is provided in Section 20.

The question of acceptability is the fulcrum in regulatory decision–making. This element is noted in section 13 (dealing with registration) via a specific reference to section 18 which cites in part D "unacceptable risk of harm" as grounds for refusal of registration. The same notion of "acceptability" is also carried in section 20 relating to suspension/cancellation.

This principle of "acceptability" is not unique in the Canadian context. The same consideration is also prominent in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Section 6(b) of FIFRA has the following provision:

> "Cancellation and Change in Classification – if it appears to the Administrator that a pesticide or its labelling or other material required to be submitted does not comply with the provisions of this Act or when used in accordance with widespread and commonly recognized practice, generally causes unreasonable adverse effects on the environment*, the Administrator may issue a notice of his intent either –
>
> "(1) to cancel its registration or to change its classification together with the reasons (including the factual basis) for his action, or
>
> "(2) to hold a hearing to determine whether or not its registration should be cancelled or its classification changed.

**The term "unreasonable adverse effect on the environment" means any unreasonable risk to man or the environment, taking into account the economic, social and environmental costs and benefits of the use of any pesticide.*

> Such notice shall be sent to the registrant and made public. In determining whether to issue any such notice, the Administrator shall include among those factors to be taken into account the impact of the action proposed in such notice on production and prices of agricultural commodities, retail food prices, and otherwise on agricultural economy."

Section 9 of the PCP Regulations sets out the types of information to be provided by the applicant to allow a determination of the safety, merit and value of the product and to guide the consideration of "acceptability" for registration. Details of the information requirements are outlined in registration guidelines and/or memoranda developed jointly by all concerned federal agencies.

In general, Canadian guidelines are similar to guidelines developed in other countries, and are consistent with international guidelines, such as those of OECD and FAO/WHO.

Re-evaluation

Older products are reviewed and updated through the re-evaulation authorities of the regulations. One of the greatest challenges is how to handle re-review of older pesticides. In 1984, with the cooperation of advising departments, Agriculture assessed the quality of data supporting the 500 registered pesticides, and ranked them into 5 categories; A – acceptable data base to F unacceptable (chemicals under re-evaluation). The ranking was done by choosing 6 key performace characters to determine risk, and evaluating this in terms of volumes of use. The study showed that the data base on 10% is fully acceptable to modern standards, 45% is fair, 25% poor to critical and 20% unacceptable (those pesticides under re-evaluation).

A priority scheme for re-evaluation has been drawn up, and new re-evaluations will be declared for 1988. This is in addition to the 25 currently undergoing re-evaluation, a process which can take 4–5 years. Under current scheme and current manpower in advising departments, it will take 15 years to complete the C level chemicals.

Further mechanisms are being investigated to determine possible acceleration of the process:

(a) cooperative reviews with EPA on other pesticides
(b) a data call-in process – coupled with the requirement for reporting adverse effect
(c) request for more resources to speed the process

Compliance Activities

Post-registration activities centre on ensuring continued safety in use. In February 1988, the old Compliance Unit became the Audit and Enforcement Section with responsibility for investigations, field compliance programs, education and assurance of continued product safety and food safety. It liaises with federal and provincial pesticides specialists in each province and with federal agriculture inspectors to deliver programs. Activities include: investigation of complaints, prosecutions, product verification, microcontaminant analysis, field monitoring and audit programs, as well as safe use surveys and education programs. Monitoring programs for 1988 include pesticide residues in food commodities, sampling of farm well water, and audit of research permit trials. A pilot audit program to ensure quality control and good procedures in formulation plants has been carried out and will be expanded as experience is gained.

Ongoing Challenges in Pesticides Regulation

The Minister of Agriculture has recently announced his intent to conduct a major review of the pesticide process.

In the interim, other changes are being pursued:

(1) Changes to the Regulations

Currently, activities are underway to strengthen PCP Regulations by amendment. These include further refinements to our Product Specific Registration policy (PSR) required reporting of adverse effects, registration provisions for all technical active ingredients, addition of formalized research testing requirements, etc. Changes to the appeal board structure are also under consideration to find ways and means to avoid the time and cost limitations associated with review board procedures.

(2) Development of Groundwater Strategy

In the environmental field, the major challenges will be the development of new environmental guidelines and strategies to adequately reduce the environmental impact of pesticides. Currently, registrants of pesticides with possible environmental impact are required to carry out environmental studies under Canadian conditions to determine fate and mobility, as per guidelines produced co-operatively with Environment Canada and Fisheries in 1986. Ongoing endeavours include revised environmental toxicology, disposal and toxicity on aquatic plant guidelines.

A big challenge is to determine the extent of groundwater contamination by pesticides.

In reducing groundwater contamination, it is our opinion that the establishment of advisory levels is a last step to be considered. Our strategy is to try to reduce the possibility of pesticides reaching water, e.g., better application methodologies, label restrictions and guidelines on use in sensitive areas, and possible restrictions on highly mobile compounds. The Department has several endeavours currently which include both research on pesticides movement and bound residues, and regulatory strategies. In many of these activities there is very close cooperation with Environment Canada or provincial environment agencies.

A project to identify areas of greatest potential for groundwater contamination is near completion. It has identified those pesticides most likely to be mobile and move to groundwater, soils with characteristics most likely to favour leaching and linked these to known groundwater aquifers. By linking pesticides to cropping practices in these soil/aquifer zones, areas with greatest potential for groundwater contamination have been identified. Efforts are now underway to develop monitoring schemes to use this data, in cooperation with Environment Canada and the provinces. This is, we believe, an important step in developing a long term strategy for minimizing contamination of pesticides in water.

(3) Aquaculture

Many products reported to have been used in the rapidly growing aquaculture industry have not been regulated. The Aquaculture Branch of Fisheries and Oceans recently advised that most of these products fall into the category of drugs subject to regulation under the Food and Drugs Act. However, a few of these products are subject to regulation under the Pest Control Products Act, e.g., control agents such as Neguvon, and others are likely subject to the Federal Fisheries Act or the Environment Contaminants Act. Due to the relevance of each of these separate pieces of legislation to the aquaculture industry, all four Departments will need to work to develop regulatory policies for this new industry.

(4) Dioxins/PCP's in the Environment

Contribution from pesticide use to the overall dioxin load is diminishing. Verification of dioxin origin, real or potential effects, and significance of levels will be increasingly important as legal elements. Scientists and regulators must not contribute to distorted perceptions and recognize the incomplete and inconclusive nature of much of the information on these controversial impurities.

(5) Biotechnology

Finally, legislation must be responsive to new technologies, including, the newest challenge, registration of pesticidal products of biotechnology. Existing legislation will cover biotech products, from importation to registration and compliance and will compliment the provisions for regulation of other products of biotechnology outlined in the new Canadian Environmental Protection Act.

Attention is currently focussed on developing guidelines for the release of microbial and genetically-engineered products. The microbial guidelines are considered an adequate first step for regulation. Attention will focus on the product to be regulated, as opposed to the process of manufacture, which is considered to be only one component of the product. A description of the transfer process and the genetic manipulation will be required, but concerns will centre on the possible effects of the product – its survivability, its competitiveness, etc., in the environment. In some cases, where the genetic transfer is clearly defined by known sequenced codons, there may be more confidence in product safety, than there would be for newly-isolated "naturally occurring microbes". Data requirements in these cases will be appropriately less.

CEPA

Finally, a few words about the new Canadian Environmental Protection Act. CEPA will provide for more equitable regulation of other toxics which have potential environmental impact. We welcome this, because it has been sometimes hard for us to justify expensive environmental testing for pesticides when other toxic substances have been pointed out to be virtually unregulated. We are pleased that there have been moves to harmonize requirements across government, especially in the biotech area, and to clearly define requirements and regulations.

Summary

In conclusion, as we change and modernize the PCP Act and Regulations, as CEPA is promolgated, there is a good legal basis for control of toxics in the 1990's and onwards.

The chief challenge in pesticides regulation will be the reevaluation and possible cancellation of unsuitable older pesticides from the market, and increased attention to pesticides management programs to better use the ones remaining. Finally, the Department is encouraged by the increasing emphasis on narrow spectrum, environmentally safer new products and biological agents which are becoming available and will allow replacement of our current heavy dependency on traditional chemical pesticides.

PEST CONTROL PRODUCTS ACT
THE ROLE OF BIOLOGY IN THE REGULATORY FRAMEWORK

** The viewpoint expressed by Dr. Lerer is personal, and is not necessarily that of Environment Canada.*

by

Dr. Harvey Lerer, Chief
Pesticides Division
Commercial Chemicals Branch
Environmental Protection
Conservation & Protection
Environment Canada
Ottawa, Ontario

The role of biology in any regulatory framework can be discussed from two quite different and distinct points of view as follows: 1) The expectations that regulatory agencies place on science and technology and 2) The constraints that must be accepted by science when it participates in the regulatory process.

The first point can be addressed under three general topics:

1) Endpoint
2) 80/20 Rule
3) Polluter Pays Principle

1. Endpoint

The purpose of any regulatory framework, e.g., Pest Control Products Act, Canadian Environmental Protection Act, etc., is to control chemical substances that have the potential to be hazardous to the environment and/or human health. Any science that is conducted for regulatory purposes under these Acts must reflect this "endpoint" i.e., to provide the regulator with sufficient, scientifically valid data on specific chemicals so that decisions can be made on the suitability of the use of these chemicals in Canada. The regulator has no interest in data for chemicals which are not or will not soon be regulated. For example, DDT and other chlorinated hydrocarbons such as toxaphene are no longer registered under the Pest Control Products Act in Canada. Therefore, there is no need for the scientist to provide the regulator with data on these chemicals – the framework for that work does not exists within the context of this Act.

2. The 80/20 Rule

It is not necessary to know everything about a chemical substance in order to make a regulatory decision. For example, if the use of a chemical results in concentrations in the environment that eliminate desirable species, the regulatory decision is simple, i.e., either lose the desirable species or get rid of the chemical. In this situation, it is not necessary to determine the toxicities of lower concentrations of this chemical nor to develop analytical techniques which allow the detection of the chemical at concentrations below lethality. These scientific data may provide the final 20% of the missing information, but are the most expensive part of the information base to generate.

3. Polluter Pays Principle

The basic premise of this rule is "do nothing that you can get the proponent to do", and is illustrated by the following example. The development and marketing of a new pesticide costs the proponent approximately $30 Million and 10 years of work. The Pest Control Products Act requires that all information required for the pre–registration evaluation of a pesticide is entirely the responsibility of the proponent. Obtaining this information can be very costly, but the pricing of these products after registration can be designed to recover these costs as well as a reasonable profit. By making the proponent responsible for this information assures that the user, the polluter, pays both the cost of development and the cost of regulation.

The government's responsibility in this process is to 1) clearly define the information that is required of the proponent 2) assure that the information that is asked for is the information that is required 3) develop the protocols to enable the proponent to obtain this information, and 4) audit or "spot check" the data base received to ensure its validity and reproducibility. In the reevaluation of in–use pesticides, the government must document reason for concern beyond the theoretical. The proponent must then provide evidence 1) to show the concern is unwarranted or 2) that the hazard can be alleviated within the use–practices associated with the product or 3) that the benefits associated with the use of the product far outweigh the risks (with the qualifier that some risks are unacceptable regardless of the benefits accrued through the use of the product).

In addition to the development of an audit program to allow the government to ensure that the protocols and practices used by the proponent and/or contract laboratories conform to scientifically acceptable laboratory experimental practices, government scientists should be involved in the development of bioevaluation techniques. It is here that the distinction must be made between biomonitoring and bioevaluation. Using sensitive and sophisticated analytical techniques, any toxicant can be found at detectable levels in the environment. However, such chemical analyses are expensive and do not answer the essential question "What is the effect?". That is the role of the biologist. We must develop sensitive, cost-effective biological screening tools for the initial evaluation of effects in the environment. If a problem is detected, we may then decide to pursue the problem in more detail utilizing more sophisticated analytical techniques.

Government scientists should also be working toward the development and, most importantly, the validation of surrogate systems, i.e., predictive mathematical models, the use of indicator species and metabolic indices to monitor stress, etc. Such systems will allow the identification of potential problems well before a chemical is released into the environment.

In a brief consideration of the second point considered at the beginning of this paper, science can provide answers to regulators on the question of effects; however, it cannot decide whether the benefits of the use of a specific chemical outweigh the risks. This is a social question and it is the answer to this question that regulators and in fact all "risk takers" must decide.

QUESTIONS TO F.Y. CHEN AND HARVEY LERER

Q.Rick Scroggins, Environmental Protection, Ottawa, Ontario

I can't help thinking that you were very hard on the researchers, but there is one thing I have noticed since I've been with Environmental Protection – there is a problem on both sides. The regulatory people are not very good at communicating what they want to the researchers.

A. Harvey Lerer

Yes, that's true. Regulators are not very good in defining the requirements in language that researchers understand. Just as regulators are not very good sometimes at understanding what the research scientists are telling them as well.

Q.Peter Wells, Environmental Protection, Atlantic Region

You indicated that you don't need to know everything in order to run a regulatory program. I agree with that and the statement that you use only information for the particular problem at hand. The problem that I have with that is that we have had problems with the pesticide formulations in the past in Canada where we've diligently approved them, used them, sometimes in many, many tens of thousands of pounds per acre and then discover through research that the problems were not with the pesticide per se, but with the formulation, e.g., matacil and spruce budworm spray program.

A. Harvey Lerer

The focus of my remarks is centred on the direction of science towards a regulatory framework. I would be very disappointed in a department that did not allow for the development of fundamental research. My comments were in terms of the regulatory framework and the kinds of science that is needed to make regulatory decisions at the time.

Q. Alan Jones, May–Baker Canada Inc.

What I have been hearing is that there is a presumption that we can regulate substances that are given a clean bill of health using best available evaluation techniques today and prevent future problems. History would show us very clearly that even though we do a good assessment now the causes come much later and are usually unpredictable. We assume that we can regulate and we must do the best job that we possibly can. Let me use the analogy of our health and welfare colleagues – acute toxicity tests are good for poison control but health evaluation now concentrates 90% of its efforts on long–term studies. Environmental scientists must somehow catch up with our Health and Welfare colleagues and start to look at biological tests which will predict long–term effects. Remember that there is a difference between being wrong and making a mistake. One can make a mistake but it is the essence of time that over time most researchers will be proven wrong. You cannot devise a regulatory system that will prevent the wrong interpretation but you can try to devise a regulatory system where you minimize the mistake.

Q. Malcolm Clark

I would like to point out that no matter
how much you register products, you cannot
prevent misuse.

A. Harvey Lerer

Absolutely.

Q. Don O'Shaughnessy

If every regulatory agency were to state as clearly as Commercial Chemicals Branch has in their recent issue of Guidelines for the Registration of New Pesticides requesting specific data, I think that both regulators and industrial representatives would be happy.

CRITERIA FOR WATER QUALITY ASSESSMENT

by

D.M. Bisset
Environmental Affairs
Shell Canada
Calgary, Alberta T2P 2H5

This paper will focus on water and the methods of assessing its quality; bio–monitoring of effluent materials is one aspect of this large problem.

Shell Canada has a policy on "Health, Safety and Environmental Protection". This policy states that, "No activity in Shell Canada is more important than ensuring that practical and effective measures are in place to protect the health and safety of our employees, customers, contractors and those who live close to our operations." Through commitment to this policy we, "apply appropriate measures to minimize any adverse effects of our operations on air, water or soil quality and to plant and animal life". To date we do not have a specific policy on biomonitoring procedures.

Shell operates a number of oil refining units across the country. Lately we have been decommissioning the unit at Oakville, Ontario. This plant was built as a state–of–the–art refinery in 1962, and now it is closed. As the state–of–the–art required, at the time of construction, the unit was built with extensive water treatment facilities. These included oil removal and biological treatment of soluble compounds in an aerated lagoon. Equalization was provided and the final effluent was discharged to Lake Ontario after monitoring for the usual parameters of BOD, COD and suspended soils as well as monitoring for toxicity in a continuous flow chamber using trout. Later, as the refinery operations became better defined and in–plant controls were shown to be effective, continuous monitoring was discontinued. The toxicity was routinely checked and it was found that existing controls and measures were more then adequate to maintain environmental control.

In 1985, Shell opened the Scotford refinery, near Edmonton, as the current state–of–the–art refinery. This unit has almost no water effluent; about 700 cubic meters per day rather than 250,000. It has a number of in–plant controls on the water that is produced. The process effluent consists of boiler blowdown, ion exchange unit backwash and about 5 to 7 gallons per minute of the flow from a secondary sanitary treatment plant. Storm water is handled separately and treated before discharge to the North Saskatchewan River.

Thirty years of technical development have led to many changes. In those same thirty years the St. Clair River has been observed closely in a very large biomonitoring experiment. Biological observation of the river indicated that at one time it was stressed, that fish had a peculiar taste, and that species diversity had declined. A concerted effort by industry and by the Lambton Industrial Society created a large change and the river is now in good condition. Industries on the St. Clair have treatment facilities, facilities developed to meet the needs of the industry and to protect the river. Virtually all effluent is treated in biological oxidation processes with separation of solids and oils. Phenolic materials are removed easily and to a very large extent.

The BIOX units are the biomonitors on these petrochemical plants. The effluent is tested routinely for BOD, COD and TOC and irregularly for toxicity to other organisms. The standard method for Oxygen Uptake Rate on the feed to the BIOX unit is an excellent measure of toxicity in these units (although not the best of biomonitoring procedures), and is routinely used in many of them. Observation of the treatment plant operation and the various analytical parameters of the effluent have allowed the plants to not only practice the four R's (reuse, recycle, remove, reduce), but also to apply specific treatments to special problems. Activated carbon has been used to advantage in combination with biological procedures for example.

Effluent testing is routine. The question may be asked, "Is it enough"? The examples of Lake Erie and the St. Clair River would indicate that we are certainly on the right track in controlling the environmental impact of our discharges. Lately, however, there has been a growing media concern for "CHEMICALS" in these waters. People have become emotional when they heard there were thousands of materials in the lakes. I last heard the number of 3,000, and I am not surprised, for this is only a measure of our ability to analyze, not a measure of the risk associated with any one of the chemicals. Many materials have been in the waters for a long time, and many are naturally occurring materials that may always be expected to exist in natural waters. It seems to me that the number is not significant. What is significant is the impact of any or all of these on the receiving waters as compared to the use for the water. It is a question of concentration, extent, duration and frequency of an impacting material that is deleterious to some observable level.

Let me change the approach to the problem and consider the regulatory process and how it applies to the problem of water quality and to biomonitoring.

The United States has a generally accepted procedure for biomonitoring and proposes the use of up to three species: Rainbow trout, bullhead minnow, Ceriodaphnia, and a plant, with an algae species also a possibility. The procedures are set out in some detail in US EPA publications so that the States may adopt any or all of them. Mixing zones are defined as are water quality standards that may be applied to lakes, rivers and streams. Legislation is available through the US Clean Air Act and the US EPA has the mandate to write and to enforce regulations. Regulations and enforcement procedures are in place and economics and the legal process in the US determine the extent of utilization of the biomonitoring system for effluent control.

The OECD has published guidelines for "ECOTOXICOLOGICAL TESTING". Their objective was concerned with the monitoring of chronic toxicity in the environment with multispecies.

OECD guidelines include protocols for measuring growth inhibition in algae, reproduction in aquatic invertebrates, and acute toxicity in fish, as well as guidelines on bioaccumulation and biodegradation of organic chemicals.

The only parameters that can be measured routinely, reliably and be interpreted are: mortality, reproduction, and growth. Chronic studies on multispecies are not easily done and so single species tests with laboratory conditions are used to establish the concentration–effect relationship for a defined time period.

A three step process has been proposed:

1. Basic level – Used to determine possible effects on a few functionally important types of organisms; ecological function is more important than "representativeness" of a species for its environment.

2. Confirmation level
3. Definitive level

The disadvantages of this approach include:

- proven research is necessary to develop multispecies tests

- the tests are not precise because of variability within populations

- standardized methods have little relevance from an ecotoxicological point of view because they are arbitrary in the assumption of the parameters to be standardized

However, the stepwise approach is useful for the assessment of effluent characteristics and it has been described by Kimerie of Monsanto as the "tiered approach" for assessment.

Tier 1 – screening for effluents with less than a dilution factor of 10,000, an acute margin of safety of 1,000, and a 14 day–Daphnia chronic margin of safety of 100.

Tier 2 – predictive for an estimate of the variability of plant operations, species sensitivity, and chronic toxicity.

Tier 3 – confirmation work on site with actual conditions.

Tier 4 – field studies upstream and downstream using ecological parameters.

The USA and the OECD have proceeded into biomonitoring testing for their own reasons. For Canada, I suggest that it is important to develop a long term environmental and ecological philosophy that fits the wide diversity of needs that exist in our ecosystem.

The current emphasis in Canada is upon enforcement procedures rather than on abatement and socially beneficial ecological management. I deplore the approach but it is politically saleable these days.

Canada is in an interesting position. We have had biomonitoring for many years using the rainbow trout 96 hour lethality test. Biomonitoring has been a useful adjunct to the routine effluent tests we do. The concept is accepted.

I propose that Canada has the opportunity to optimize the use of its water resources and to continue the development of the studies of MacLaren on Canadian water resources (the Pearce Commission).

The Federal Government is well suited to the development of:

1. Water quality standards and criteria

2. Effluent characterization test methods and procedures

3. Watershed quality standards, evaluation procedures and monitoring

4. Socio–economic benefits assessment of water usage

I expect that we will want to build new process units and to do this we need a water policy in Canada – a policy on water discharges.

I propose that we use a receiving water approach. Nelson Thomas spoke of this as the US EPA 208 study approach. This requires the evaluation of the intended uses of watersheds and the development of effluent discharge criteria for each. It requires the monitoring of the waters to see that the quality is maintained and that the defined inputs are acceptable. There can be no exceptions for non–point sources or special interest groups. This approach would seek abatement of effects or reduction of impacts and would use enforcement as necessary to maintain the defined quality standard.

Rather than leading to pollution havens, this will lead to the development of controlled industrial areas.

There is a need for a policy document on the management of effluents.

Important to this approach is flexibility. Flexibility in regulations that:

- allow monitoring procedures to change

- address standards not the details of measurement

- use a statistically significant set of control levels

- emphasize not analysis but the development of minimum impact

- refer to effluent testing procedures and guidelines that have been developed on a consensus basis within Canada

Socio-economic analyses are important to this discussion for all human activity will impact on the environment and choices have to be made. An example is the new refinery with only increased dissolved solids in its effluent. Dissolved solids will impact on the freshwater biota in a mixing zone and the effluent could be toxic to some of the biota. The alternative of removing the dissolved salts prior to discharge may very well increase the total environmental impact of the production unit. The pretreatment may consume more fuel, resulting in more CO2 emissions. Land may be required to process the material and to store the waste product. It is important to consider the broader aspects of human activity in the context of environmental management.

There is one other large concern. It deals with our ability to assess, define and to communicate risk to the public. We have not been successful to date. The report "Toxic chemicals in the great lakes basin ecosystem", is a scary report, but the risks of the existence of chemicals has not been evaluated or well explained. I would be concerned with our inability to explain the result of fish or other organisms dying in a biomonitoring experiment. I am sure that the technical explanations will be correct and understood in the scientific community...but will it be explainable in the local media? Let me close with a plea for increased education of the public and increased communication with all of those concerned (the stakeholders) so as to explain risk and the part they and science have to play in the protection of our way of life and our water resources. Increased communication of the social costs and benefits of our way of life is necessary.

APPLICATION OF BIOLOGICAL TEST METHODS FOR EVALUATING COMPLEX EFFLUENTS

by

A.A. Schuldt, Manager
Environmental Control

Stelco Inc.

INTRODUCTION

Biological assessment of complex effluents is a timely topic especially since the concept will be part of new regulations which are being developed in Ontario under the Municipal Industrial Strategy for Abatement of toxic chemicals (MISA). Biological testing is to complement intensive chemical examination of effluents. The objective of MISA is to control the discharge of toxic substances into surface waters.

Biological testing tends to trigger different images. It is rather a complex tool and results are not obtained quickly. Data must be interpreted by skilled specialists. It is not a very practical operating tool that may be used for controlling water treatment facilities.

Biological monitoring programs are really site-specific programs as they must take into consideration the nature of the effluent, processes that are involved and location of discharges. As a consequence any regulatory initiative which would include biomonitoring creates difficulties. Also, this form of monitoring is expensive, this should not come as a surprise. Specialized equipment is needed which normally is not available at a plant site. Very often, testing must be done elsewhere. This would require the shipment of a lot of water.

On the other side, biomonitoring can provide useful information and costs may even be justified. For instance, fish exposure studies have been used to demonstrate graphically that water quality is satisfactory for direct discharge when there is no fish mortality. Such results further strengthen any interpretation of chemical test data. The mystery of water chemistry is removed when a fish is observed swimming in an effluent. Another point would be that the level of treatment provided is more than sufficient.

As well, biomonitoring has been used as a warning device for detecting deterioration of water quality. Also, the technique may be used to identify the cause of problems.

It seems biomonitoring has a supplementary role to play in specific circumstances and for specific reasons. There is a vast difference in approach if biological testing is done for investigative purposes, if done for compliance monitoring or done for assessing the impact of an effluent on a receiving water body. It is difficult to visualize how biomonitoring can be regulated in a practical and reasonable manner. Certainly flexibility is required and codes of practices are needed.

COMPREHENSIVE BIOLOGICAL TESTING

Here is an approach which was developed to satisfy a biological assessment of an effluent from a greenfield integrated steel plant. The program was specifically tailored. The guiding principles were:

- identify objectives
- retain qualified people
- define program
- define procedures
- make allowances for contingencies
- keep stakeholders informed

The comprehensive monitoring program involved:

- acute and chronic testing
- flow–through and static testing
- on–site and off–site testing
- standard aquatic test organisms
- indigenous aquatic test organisms

The study examined:

- reproduction stress
- growth rate inhibition
- embryonic development
- hatchability success
- avoidance behaviour
- taintability
- life cycle interference
- bioaccumulation

The results of the study indicated that the treated effluent is non–toxic to fish. Sublethal testing indicated that indigenous organisms residing in the receiving water are not stressed. Water treatment systems performed as designed.

The investigation spanned a six year period at a cost of about $300,000 Canadian for one plant with a single discharge point.

Biomonitoring takes patience, substantial resources and a clear appreciation of objectives.

POINTS TO CONSIDER

In view of the current regulatory initiatives, it is important to realize that biomonitoring is a complex evaluation process. It is not a simple process as live aquatic organisms are used. Responses vary and interpretation of data can be a problem. Biological assessment programs are evolving. Procedures which are judged acceptable today may turn out to be inadequate later or they may not be transferrable to other situations. Flexibility has to be retained. Once requirements are enshrined in regulations, flexibility is lost.

Some key points are:

–biomonitoring should be realistic and focused to avoid generating unnecessary information;

- standardized procedures are required;
- guidelines for data interpretation are required;

- guidelines for selecting test organisms are required;

- qualified laboratories are needed for performing the work.

Even though aquatic bioassay testing is not new, any regulatory initiative should proceed continuously. The role of government should be to develop in co–operation with industry the appropriate standards, protocols, etc. for performing biological tests. In view of the new proposed regulations, biological monitoring should be seen as a safety measurement and not as a tool for enforcing hard effluent limits. The role of biomonitoring is complementary. It is a screening device to provide information for developing appropriate programs for the chemical testing of effluents.

INTRODUCTION OF NEW ENVIRONMENTAL BIOLOGY TESTING INTO THE REGULATION OF CROP PROTECTION CHEMICALS

by

Allan G. Jones
May and Baker Canada Inc.

This paper will focus on the ambient release of crop protection chemicals when used in accordance with label directions, rather than the point source discharges discussed so far.

First, I would like to comment on two areas of previous presentations.

Several speakers seemed to regard as synonymous the words "industry" with "polluter" and "product" with "pollutant". The chemical industry has made significant advances in recent years in accepting its responsibilities for the environmental impact of its products. Consistent use of the phrases "polluter" and "polluter pays" by government speakers in this manner is less than helpful in encouraging good working relationships between industry and regulators.

Secondly, one speaker suggested that researchers concentrate on developing test methods for industry and not become involved with their subsequent use. I disagree. Regulators and researchers should have the broadest possible background to their activities or actions, no matter how specialized a field they may be working in. While industry and regulators discuss science issues and policies, their different background issues are divergent. I encourage my colleagues in our industry to understand the needs of regulators in terms of quantity and quality of data on which regulatory decisions can be made. I also expect regulators to take the trouble to understand the economic issues facing industry in undertaking the required scientific studies.

I shall be discussing the Workshop subject under three main headings:

First, comments on possible new areas of study related to the use of crop protection chemicals.

Secondly, some comments and suggestions on the way in which new studies should be brought into the regulatory framework.

Finally, some comments on the associated economic issues for the crop protection industry and the impact of adoption of new study requirements.

In terms of definitions, I have divided the subject of environmental biology simplistically into 'environmental toxicology' (the effect of the product on specific target species, often at exaggerated doses) and 'environmental bioassessment', (the use of biological monitors to determine the levels and distribution pattern of a chemical product and its effects under real use conditions).

Current data requirements for environmental toxicology studies for Crop Protection Chemicals are listed in Agriculture Canada's memorandum T-1-237. This memorandum covers routine requirements for acute toxicity studies, usually conducted using two fish species and a fish food source, Daphnia magna. Provision is also made in the Memorandum for requesting additional studies with longer term exposure or for establishing effects on reproduction. At present there are no detailed guidelines for environmental toxicology studies comparable with the environmental fate guidelines (Memorandum T-1-255) issued recently covering the subject of terrestrial fate. As crop protection chemicals are developed on an international market basis, often there are additional acute aquatic toxicity studies available for review in Canada, conducted to meet regulatory requirements in other countries; e.g., Japan has different requirements for fish toxicity studies. While previous speakers have referred to Canadian and U.S.A. data, no-one has yet referred to more international study requirements in the area of aquatic environmental fate.

In identifying possible changes in this area, two particular lines of development are suggested:

First, the extension of acute studies to other test species in the aquatic food chain, either species thought to be under environmental pressure from chemicals or tests in biota with particular chemical sensitivities. Identification of individual test species and the basic test methods would be a useful first step for government and academic research institutions.

Secondly, expansion of study techniques to cover sub-lethal effects, including behavioural and pathological parameters where relevant, could be a more sensitive approach to relating toxic effect and exposure.

Environmental bioassessment techniques have the potential to show not only the presence of low levels of a chemical, but also actual effects under real exposure conditions. Such studies can be broad-spectrum, covering the total adverse effect on the target species from all exposures or they can selectively correlate changes in specific chemical levels in waterways with effects on particular aquatic organisms, water fowl or habitat.

It is reasonable to expect industry to be directly involved in the development of bioassessment study techniques relating to their specific chemical products. Equally, it is not reasonable on a regulatory basis to expect companies to undertake research of a fundamental nature unrelated to their specific products.

Large scale field studies using chemical or bioassay techniques should be used for post-registration monitoring. Large-scale environmental impact studies of regional interest, for example, the Yamaska River study being conducted at present by Environment Canada, may provide valuable insight into the effect of chemicals on a particular water system, but I cannot see any basis for introducing such studies into the regulatory agenda. Their cost and duration would make them prohibitvely expensive for most companies developing crop protection chemicals in Canada. The interpretation of results within a regulatory context and the impact of multiple contaminant sources in the water system on particular organisms make these studies of limited applicability for pre-marketing registration purposes. I recognize that these studies could play an important role in monitoring the changes in aquatic impact on specific water systems and in this sense I see them as a post-registration monitoring tool akin to the 'foodbasket' surveys undertaken by Health and Welfare Canada for crop residues. Most companies, I am sure, would be cooperative in the development of any assessment procedures for their specific products for use in such studies.

Any new study introduced into the environmental biology area, should include the development of assessment criteria as well as study design. Too often we see regulators requesting a study on the basis of scientific curiousity rather than that study contributing significantly to their decision–making ability. While companies may often be prepared to undertake research to answer questions of scientific interest, I do not support the use of regulatory controls in this context.

Environmental biology studies should be integrated into the Environmental Fate Guidelines. Now let me turn to the adoption process. Agriculture Canada recently released formal guidelines for environmental impact assessment in trade memorandum T–1–255. T–1–255 currently focuses on laboratory and field studies covering environmental degradation of the chemical and its field persistence properties. I would recommend that any additions in the area of environmental biology should be integrated into this document.

My reasons for recommending this action are two–fold. First, from the viewpoint of ambient release of crop protection chemicals, we cannot separate their environmental fate in soils from their impact on surface waters, through runoff or soil erosion, or their impact on groundwater. Therefore, the process of regulating environmental fate under the Pest Control Products Act should be encompassing, focussed and integrated. Secondly, I feel that integration of test requirements, by determining the best study method to achieve the end–point, will also be of benefit to industry.

I emphasize the word integrated. We must ensure that the introduction of environmental bioassay studies does not become partisan or lobbyist, resulting in duplication of test requirements. If the result of introduction of biological techniques into environment fate requirements is to end up with duplicated studies using traditional analytical procedures and bioassay techniques to achieve the same end–point, an opportunity for sensible regulatory development will have been lost.

New studies introduced into formal regulatory context must be shown to contribute significantly to the decision making capability of regulatory personnel.

The adoption process should foster the development of adequate commercial contract resources in Canada to undertake such studies. Within the Crop Protection sector, throughout Canada, we employ fewer people in all technical roles than are currently employed in the CCIW building in Burlington; we are heavily reliant on corporate R&D centres in Europe and the USA. For specific new studies, with primary applicability within Canada, we must encourage the creation of local contract study resources to meet our needs.

For new environmental biology techniques, we must ensure that test facilities are available to industry prior to introduction of study requirements, and not use the introduction of such studies as a lever on industry to develop the resources. I believe that clarification of study techniques, coupled with strong collaborative contact between researchers and test facilities to promote the development of these techniques, are a pre–requisite phase to regulatory adoption.

New study requirements should take account of the balance of crop protection chemical usage in Canada. The majority of our product use is herbicides and insecticides for field crops in the prairie provinces. Studies designed to assess the aquatic impact of agricultural chemicals in prairie water systems must be an important consideration in guideline development.

Potentially, environmental fate studies can be restricted in regional applicability to the extent where multiple repetitions of the study will be too expensive to justify any one product's development. While no two areas are the same, I believe that regulators must be encouraged to extrapolate each study to regions where reasonable comparisons can be made.

My final subject is the economic impact of the introduction of new studies in the area of environmental biology.

The Crop Protection Chemical market is in decline; sales figures for the industry show how, over the last 3 years, sales have dropped. Much of this is accounted for by the economic plight of western grain products. However, if a company is earning less year by year from the sale of its products, it is less able to absorb the cost of new development requirements. This problem may well affect other chemical business sectors to be regulated under CEPA.

Absence of a phased registration system. Contrary to many other countries, in Canada we do not have a practical 'phased' registration system for crop protection chemicals, where limited sales, restricted by quantity or time, can be made on the basis of a limited data package. Under this limited registration procedure, additional studies, particularly those associated with longer–term risks, must be completed to ensure that a full registration of the product can be obtained.

Some environmental studies, particularly the area of costly field studies, fall within this category, where they can often be conducted under commercial use conditions. The absence of a phased registration approach is a serious handicap for affected industries in this respect.

In summary, I believe that the current costs of meeting the registration requirements for crop protection chemicals are already excluding the introduction of new products into a number of Canadian crops. Any increase in study requirements and costs will reduce further the number of new products entering Canada, with particular effect on crops in Eastern provinces and British Columbia. This will inevitably decrease the competitiveness of growers within these provinces.

Therefore, we must include the economic constraints on companies producing new crop protection products in the overall picture of new study requirements for regulatory decision-making if we are to meet the needs of the Canadian grower and, ultimately, the food requirements of Canadians.

QUESTIONS TO DOUG BISSET, AL SCHULDT AND ALLEN JONES

Q. Mike Veroust. Canadian Pulp & Paper Association

I would just like to make a comment. I think that it is probably worthwhile repeating that with the consideration of moving biological testing into environmental requirements, economics are a very important aspect. The last speaker emphasized this point – that industries must be fully cognizant of what they have to do to comply with these requirements and the cost involved. There is no argument that we are all in favour of protecting the environment and there is probably a consensus that biological information is absolutely necessary. It is useful and it provides us with a lot of good information which is going to be used in developing abatement measures, but we still have to keep our eye on the economics and on practical requirements.

Q. Are you saying that in your opinion the regulators are not keeping this in mind or is this just a cautionary note on your part?

A. Possibly both.

Q.Peter Hodson, Department of Fisheries and Oceans

The first few speakers were concerned of course with end-of-pipe or effluent monitoring and I think they both implied or stated that when water quality was satisfactory, based on the survival of fish in 100% effluent, that effluent could be discharged. I think perhaps most of us would accept that. But I think we also will be rather naive to assume that that indicated environmental protection. I was wondering what industries' view would be for a suitable audit to ensure that we actually do have some sort of environmental protection? What sort of tool should we be applying for environmental protection?

A. Doug Bisset

I don't think that I was suggesting that as long as you could satisfy the trout test that was satisfactory. I was proposing that there be a broader water policy approach. I think that it is up to the people who live in various watersheds to determine the use for that water and what risks you will accept. Any human activity in that area whether it be recreational activity or industrial activity is going to have some impact on the water. You may have to go to the people and ask "What will satisfy you? Will you accept industry and the impact in this region?"

A. Allan Schuldt

I would like to make just one point and that is perhaps that that question is premature in the sense that you are speaking of "What would industry do to ensure that we have met the beneficial use requirement?" cannot be answered because we haven't identified yet what the beneficial use of that water is. But perhaps I could add to that as follows: if you assume that the water body into which you discharge is a fishery, then I think it would be quite reasonable to say that you must do something towards demonstrating that the effluent is not impacting on the fishery, i.e., the trout survives in the effluent.

Q. Peter Hodson

I think my question was really driving towards the problem of the simplicity of the effluent test relative to the complexity of the real world. For example, PAH's will not have an acute lethality to fish and may not even bioaccumulate in a standard toxicity test, but these materials are concentrated in ecosystems and have some detrimental effects. So it would appear that while we can control some things through specific biological monitoring programs for effluents, there is no guarantee that there is no environmental impact. There is obviously a need for some further forms of environmental monitoring and I was wondering whether you had some?

A. Well, I think that you partly answered your own question in the sense that you identified that biological monitoring will not answer everything.

Q. What I would like to see in your next presentation is a table describing how much water is required to produce one ton of steel and how much is the cost for recycling that particular water? Hypothetically-speaking, if the steel industry today had to face a dilemma that instead of water they would have to use another common solvent (e.g., gasoline, alcohol, etc.) how would the situation change?

A. Doug Bisset

I mentioned to you the change in the oil industry in the use of water for direct cooling and the switch to the use of air cooling as we've done in Edmonton. We've reduced from 250,000 m3 to 700 m3 per day of water used by using electricity to drive fans to blow air over air coils. Where do we get the electricity? From power plants which have to use additional water for cooling in order to generate the electricity. It is much more complicated than just picking one particular point and saying "Change that". We must look at the whole picture.

Q. Harvey Lerer, Commercial Chemical Branch, Environmental Protection

I would like to make a comment on the comments. Unfortunately, I found very little to disagree with the speakers. However, just as in our science-based discussions, we've talked about the need for long-term studies and long-term effects monitoring as opposed to acute studies. I would suggest that we need to take the same perspective with respect to economics. As we go through an evolution of environmental protection, I would suggest that these environmental protection measures will in fact protect the economic base that we are so concerned about.

Q. Christian Blaise, Environmental Protection, Quebec Region

Biotests can sometimes be more costly and time consuming than chemical analyses. As Peter Wells mentioned in his talk yesterday, there has been a lot of evolution as far as biotests are concerned over the last thirty years and we have tended during that period to go for macro-biotests (i.e., tests with fish) to micro-tests (i.e., test performed with smaller organisms). Ecotoxicology is showing more and more with time through comparative studies that many of these micro-biotests can be good surrogate organisms for fish-testing and therefore the cost-efficiency is much greater than it was before. Now that biotechnology is around, there is a greater chance to have a link between biotechnology and ecotoxicology such that with microbial tests you can get very fast results. So although I might be talking science fiction right now, in the 1990's, we may well see the appearance of biotests which are very cost-efficient, short-term and which give you the same information as mini-tests give you today. I look forward to regulations via these second-generation biotests.

Q.Bill Chen, Dow Chemical Canada Inc. and Canadian Chemical Producers Association

I have heard the discussions between industry concerned about economics and regulators concerned about law and pollution and long-term economic benefits to industry and I agree with both. We, as a chemical industry, are committed to responsible care, and biological monitoring obviously plays an important part in the responsible care of the use of chemicals. But I submit to you that there is really no discrepancy between the two viewpoints. Pesticide use in Canada is very small in the global basis and use is declining. Obviously you have to take that into consideration in regulatory decision making. We must have concordance with international requirements. The second thing I want to ask is "What is the usefulness of the tests to the regulatory decision-making?" If it's an 80/20 rule as suggested by Harvey Lerer, i.e., it's more nice to know than need to know, I submit that maybe we should put that on the back-burner and use the tests that we can afford and give us the best results.

Q. Keith Marshall, Canadian Wildlife Service

I would like to make two points. I'm in the business of evaluating pesticides and other chemicals for their effects on the environment and providing advice to regulators. The first point that comes up under providing acute data and sublethal data was made by Allen Jones. Industry can provide the data required but they don't. And as a result, we are increasingly forced to try and prescribe the testing requirements to data requirements and the 'how-to'. The second point is that I believe that it is far more important to get out in the field than to be prescribing too many laboratory tests. There is nothing preventing industrial sectors from developing their own research institutes in collaboration with government to determine these generic-type problems.

A. Doug Bisset

I think that it is the intent of this workshop. It is not that industry is reluctant to make that step in development, but that it is looking for guidance from experts within other sectors to help in that process. Industry should not be totally self-starting in this matter.

ECOSYSTEM ANALYSIS AS A BIOMONITORING TOOL: A PRIVATE SECTOR VIEW

by

K. Schiefer, Ph.D.
Beak Consultants Ltd.

For the private sector, the distinction between field consulting and laboratory testing services is often quite arbitrary, however, I will restrict myself here to field applications and ecosystem response monitoring. I will be pursuing two themes here: (1) appropriateness of certain biological toxicity testing surro gates for ecosystem or ecological response, and (2) kind of tools that directly measure ecosys tem response.

My basic premise is:

"If the primary objective of environmental legislation and regulation, based on physical, chemical and toxicological criteria, is protection of the biological community of a receiving environment, it follows that direct measurement of this community is required to determine compliance."

Because laboratory testing procedures are not good surrogates of ecological response, it is necessary to carry out field investigations. Biological/ecological evaluation criteria commonly include:

Species Presence/Absence

- "indicator" or "sensitive" species

Biological Community Analysis

- diversity/dominance
- trophic level

Pathogenic Effects

- mutagenicity
- skin lesions and cancers

Generally, environmental regulatory criteria fall into two broad categories, as follows:

1. Public Health and Safety

- chemical criteria
- biological criteria

2. Ecosystem Impacts

- physical criteria
- chemical criteria
- biological criteria

For public health and safety, both chemical and biological criteria are associated with numerical values related to a specified water use. Numerical values apply also to microbiological criteria. For ecosystem impacts, although chemical data are generally associated with numerical values, it is usually not so for biological criteria.

One example of ecosystem impacts is the development of biological criteria to predict and model ecological impacts of once–through cooling systems where heat is the principal perturbing agent. A second example is the definition of habitat criteria for life cycle functions of target species of fish; this is much superior to arbitrary hydrologic criteria such as 30% of mean annual flow on a daily basis. With such a tool, the biologist can quantify habitat gain or loss relative to proposed flow regimes.

Odum (1985) defined four broad categories of trends expected in stressed ecosystems. These are:

1. Community Structure

- species diversity decreases and dominance increases
- size of organisms decreases
- lifespans of organisms decrease
- food chains shorten because of reduced

energy flow at higher trophic levels and/or greater sensitivity of predators to stress

2. Nutrient Cycling

- nutrient turnover increases
- horizontal transport increases and
- vertical cycling of nutrients decreases
- nutrient loss increases (systems become more "leaky")

3. Energetics

- community respiration increases vP/R (production/respiration) becomes unbalanced
- P/B and R/B (maintenance/biomass structure) increase v exported or unused primary production increases

4. General System Level Trends

- ecosystem becomes more open (input and output environments become more important as internal cycling is reduced)

- autogenic successional trends reverse (organization exhibits some feature similar to earlier stages of succession)

- efficiency of resource use decreases vparasitism and other negative interactions increase, and mutualism and other positive interactions decrease

Most biological testing of ambient and receiving waters focusses upon either an indicator (target) species (e.g., lake trout) or upon community structure. Use of a top predator such as lake trout is a measure of the integrity of the ecosystem in which it lives.

Community analysis has been approached in a variety of ways; it may be more or less successful depending upon the types of organisms included (e.g., bacteria, invertebrates, fish). The Index of Biotic Integrity (IBI) as employed in the Great Lakes, appears to be more relevant than other community analyses used to date. The IBI index has the advantage of producing numerical values which includes species that society regards as having economic or aesthetic value. This index requires, however, further R&D so that it can be adopted for regulatory purposes.

Use of field techniques in receiving waters reveals important dilemmas in regulatory criteria. In our experience we have seen two pulp and paper mills where one causes no measurable ecological effect whereas the other, with similar effluent, does cause measurable effect. In the latter case, the mill was discharging into waters which were already under stress. The dilemma becomes one of equality of toxicity criteria of effluent for a particular industrial group versus variable criteria dependent upon the characteristics of receiving water of each mill.

Finally, let me point out certain perspectives on the role of the environmental consulting industry. Firstly, we:

- provide impartial and objective professional services for government and industry clients, and

- are directly involved in technical confrontation between regulatory and industry objectives and perceptions

Secondly, our role in applied research into ecological testing and effects assessment flow from:

- direct familiarity with needs, issues and problems
- in the best position to directly apply new technologies and methodologies
- provides opportunities for the Canadian economy

The private sector requires support to continue to develop applied technologies which can be marketd in larger market areas such as the United States. The development of applied technologies should not be the primary responsibility of government or university laboratories.

ISSUES, CONCERNS AND OPPORTUNITIES FOR BIOLOGICAL TESTING LABORATORIES IN POLLUTION ABATEMENT PROGRAMS

by

Christopher D. Wren
B.A.R. Environmental

Nicholas Beaver Park, R.R. #3
Guelph, Ontario
N1H 6H9

In the consulting sector, there are a number of issues and concerns regarding biological monitoring for pollution abatement and it is difficult to readily separate some of the issues from the concerns. There are three players in this business, the government, industry and the consulting sector. The role of the consulting sector is to provide support services for both government and industry, to act as a mediator, and to provide expertise and advice.

Aquatic toxicity testing within private laboratories in Ontario is not new. In the mid 1970's, the federal Fisheries Act was the legislative initiative to promote toxicity testing. This resulted in a minor boom in the field of environmental consulting in the late 1970's which quickly faded away for a number of reasons discussed below. Now the initiative and legal support is coming from the Canadian Environmental Protection Act (CEPA) and the Ontario MISA program. The following summarizes some of the problems with past aquatic toxicity programs which can also be translated into current issues and concerns.

Lack of purpose and direction
Regulatory confusion
Terminology
Program confusion
Testing methodology

A few of the inherent reasons why aquatic toxicity was not rigorously incorporated into pollution abatement programs must obviously be directed at the government of the time which lacked the political will to implement such programs. When both the federal and provincial governments are implementing similar programs and initiatives, there is also real potential danger for confusion over who should do what. As consultants to industrial clients, it is imperative that we know which regulating agency is responsible for any given situation.

Terminologies such as biomonitoring or bioeffects monitoring have not been well defined and can have a variety of connotations. In this discussion, we are concerned with acute toxicity testing in the laboratory and therefore I will not define a host of other ancillary terms.

There is potential for program confusion since biomonitoring encompasses a host of activities and both the federal and provincial ministries are involved in many of these. Some biomonitoring programs include on-site trailers, caged fish/clams/leeches, benthic surveys, fish community indices, sportfish contaminant monitoring, aquatic toxicity testing and epidemiology of fish tumors. Instead of the government trying to fit their biology programs into their toxicity regulations, government should be asking "what are the objectives of CEPA or MISA? what are the data requirements? what are the tests that can fulfill these requirements?"

Inadequate testing methodology was another reason why private aquatic toxicity testing faded in Ontario. We are still wrestling with the issues of testing protocols and reliability. Some common concerns about toxicity testing include replicability, inappropriate test methods and invalid test species.

The issue of replicablity seems to be a stumbling block to some industries. There is every indication that the rainbow trout and Daphnia results are replicable, and the results acceptable within a range of recognized variability. We must utilize the data within this framework. Variability of biological tests is inherent within living organisms, but it is, and perhaps surprisingly so, within the same magnitude of order as many analytical chemical tests.

There seems to be little discussion or concern about the complex analytical techniques needed to produce values in the eg/g or ng/g range. ICP or Inductively Coupled Plasma Emission spectroscopy is a wonderful instrument that has become very popular because of its ability to simultaneously analyze for a number of metals and elements. It will always provide a value, but how many people understand the limitations of these values from one sample type to the next? The reliability of the reported values are certainly different between spiked water samples, a complex effluent sample, sediments or fish tissues. Yet how many people question the degree of interference from other elements within specific matrix types? I don't have any problems with the analytical chemists, but I do have a problem with those people who accept pages and pages of analytical results at face value and then question the reliability of acute toxicity tests. Clearly we allow the analytical chemist and engineers the responsibility to select the appropriate tests, identify the limitations of their tests, and report the results to get on with the job. We should allow the biologist no less.

Regulated industries are concerned with the cost of implementing biological monitoring and this is a genuine concern. However, on a per sample basis the cost is much less than many chemical tests, and the information obtained is more than cost effective.

Reliability and accuracy are the cornerstones of laboratory performance, and, hopefully, success within the consulting industry. It must be the role of government to design adequate QA/QC practices for toxicity testing laboratories. In addition, they must enforce the standards. Budgets and manpower must be dedicated to this task which must be a priority if the program is to be successful. The consulting sector would welcome the laboratory certification of toxicity laboratories.

As aquatic toxicity testing develops, there will be a need for newer, more sophisticated and more sensitive tests. Only the government can support the development of such tests, whether it is done in-house or funded externally through research contracts. The potential returns simply do not warrant private R&D within the consulting sector.

With the initiation of toxicity testing, the governments have an unprecedented opportunity to systematically gather and record a tremendous amount of data. However, we must be sure to use these databases and not allow them to be simply filed away on computer disks.

There is real concern that biological monitoring in general and toxicity testing in particular will get overshadowed by the engineering or Best Available Technology approach for pollution control. Part of the philosophy that would allow this to happen is the biologists simply are outmanouvered by the engineers but biologist must also have focused programs or focused objectives.

In 1979, John Cairns stated that biological assessment and monitoring of pollution effects will go through the following four phases of development:

1. Awareness
2. Observation
3. Predictive
4. Managerial

Not all phases are clearly demarcated and there is ample overlap. As new chemicals are registered or discovered in aquatic ecosystems, we will go back to the awareness phase every time. For many substances hopefully we are well into the predictive and even managerial phases. Environmental consultations are in a perfect position to help industry and government to go from phase 1 to 4.

I have mentioned a few opportunities the governments should seize upon in the areas of data acquisition and data use, and full support of R&D activities in the environmental consulting sector. The regulated industries themselves have an even broader scope of opportunities. Stricter environmental regulations are not unique to Ontario or Canada. The World Commission on Environment and Development headed by Gro Brundtland, the Prime Minister of Norway, and our own McDonald Report on the Economy, both identified a distinct link between a sound future economy and a healthy environment. Sustainable development is the popular term.

There are just concerns about equitable enforcement of environmental standards, not just between industrial sectors, but between provinces and international boundaries. These are major challenges the governments face, and they will require cooperation and political will at many levels.

The industries which are first to develop innovative and cost-effective waste management programs will in essence have a marketable product, and will also have an edge over the competition. The legal frameworks for environmental controls may be viewed as constraints and financial shackles, but it has always been the successful industry and business director that grasps such challenges and turns them into opportunities.

The need for biological testing services does provide opportunities for the consulting sector. The most obvious is simply in providing new jobs. We also have the opportunity to develop true world class facilities to conduct R&D, which are the future building blocks for any endeavour. But even more exciting, is that we are in a prime position to transfer new information and technology to the user groups and different industrial sectors.

Like any business, environmental consultants are geared to providing results. We can conduct standard bioassays and provide realms of data, but personally I would like to see it go further than that. I see consultants becoming more involved in projects influencing policy and management decisions, in both government and industry. There are many eminently qualified professionals in environmental consulting today that welcome these challenges and opportunities.

QUESTIONS TO CHRIS WREN AND KARL SCHIEFER

Q.Ed Ongley, National Water Research Institute

Are you suggesting that in order to successfully export technology, the private sector would have to do the R&D itself or were you saying that you can be more successful if you have technology and assistance in R&D from universities and government?

A. Karl Schiefer

Well, I would like to distinguish between applied research and more academic, esoteric research. I think applied research should be done by those in the position to apply it. That is not to say that universities nor the government do not have important roles to play. They clearly do.

Q. Peter Chapman, EVS Consultants

I would like to bring up an issue that is only being alluded to here, but that is very important and that is the issue of provinces versus the federal government. I represent a company that has 30 employees and 75% of our gross revenue is from outside Canada. We find it very difficult to work in neighbouring provinces. Free trade for us really means free trade within Canada. The environmental consulting business is very small in Canada and remains mainly because we are subsidized, if you like, from the United States and other countries. That's shameful because we are 100% Canadian owned. Several things result from that because we are regionalized. We have expertise in certain areas but we are not learning from Ontario and you are not learning from us.

A. Karl Schiefer

I think that you have stated the issue very well. Canadians tend to be a poor group in terms of how we cope within Canada. We have the same problems and we find it much easier to sell services internationally than within Canada.

Q. Steve Hrudy, University of Alberta

I would like to offer three comments, one directed to industry, one directed to regulators and then my view as to the university role which hasn't been addressed. I've certainly heard a lot of comments that lead us to believe that the two solitudes still exist in terms of industrial and regulators' attitudes. To industry first, I think that you need to appreciate that civil servants have a tough job in trying to provide a consistent set of rules because they jump to what their political masters tell them to do. I think that if our environmental departments in Canada were really there to protect the environment instead of to keep the Minister out of hot water, we would have a more consistent set of rules. I think that if industry could make our politicians understand that economic development and environmental protection need not be at odds, maybe our environment departments would be more effective. With respect to the regulators, I think you need to understand that the environment co-ordinators that you deal with in industry have a tough job. They may be very hard to convince of the need to do the things that have to be done, but they have to convince the people who hold the purse strings to spend the money. Anything that you can do to make their job more easy in convincing these people would do a lot for environmental protection. The third comment with respect to the role of the universities is that in addition to universities providing education, I think that they can promote better educational programs at Canadian universities to implement better biotests. Comment. Dr. Vermossi

If there is an opportunity in the consulting sector particularly internationally, they need to produce graduate students that can come into a working environment as professionals not as academic researchers dealing with esoteric subjects. We cannot afford to spend five more years training them how to be professionals.

Q. Pam Stokes, University of Toronto

I had a few notes on how universities could contribute through biology and a regulatory framework. First, of course, as Steve Hrudy just pointed out, the role of universities is that of education and training of personnel for consulting, government and industry. We are also supposed to do high-quality research and it can be done cost-effectively. We are also impartial and independent from the political scene and can provide neutral ground for discussion. On the side of disadvantages, there is no denying that there is an elitism in the science departments of universities which means that mission-oriented or targeted research is not quite respectable. This doesn't apply to the Applied Sciences and Engineering or to some extent to the Applied Medical Faculties. My institute is in a position where we can perhaps set an example of how biological and social research can be done in an applied area. We are well known for not adhering to deadlines and for not sticking to our objectives. We like to get sidetracked and do the nice to know rather than the need to know research, I acknowledge that. My recommendations are to improve communication amongst us and I hope some of that has happened today. Constructive criticism on all sides is important. Technology transfers should be part of the responsibility of a university scientist who accepts funding from government or from the private sector. The university should listen and the government and industry should provide information in terms of the training needs. There should be a recognition that universities can contribute perhaps as centres of excellence. So far this hasn't happened.

EXPERIENCES IN THE USE OF BIOLOGY IN THE CONTROL OF TOXICS IN THE UNITED STATES

by

Nelson A. Thomas, Senior Advisor
U.S. EPA, Environmental Research Laboratory

Duluth, Minnesota

The Congress of the United States provides direction in the control of water pollution through various environmental laws. The actual regulations that implement the laws are set by Program Offices. The Office of Research and Development provides the scientific basis for the regulations. With the passage of the Clean Water Act in 1972, the era of the process engineer began and discharge limits were developed on the basis of technology as opposed to Receiving Water Quality. This was the dark age of the biologist. During that period, Water Quality Criteria were not being developed, even though they were called for under the Clean Water Act.

In 1978, EPA began to develop Water Quality Criteria, and as biologists began to resume their important role, they managed to publish 65 criteria in 1980. In 1982, biologists attempted to put an acute toxicity limit into discharge permits and were quickly sued. As a result, the agency was required to develop a policy on the use of toxic substances to control toxics in discharges.

The Agency developed a series of laboratory-to-field comparisons that were used to demonstrate the ecological relativity of the laboratory toxicity tests. In 1987, with the issuance of the Clean Water Act Amendments, biology received increased emphasis. The Act required states to incorporate EPA Water Quality Criteria into state standards and toxicity limits when criteria were not available. In addition, states were required to perform water body use assessments. The states were then required to develop individual control strategies to provide for attainment of the designated use. These control strategies were to be based on achieving a desired water; thus the phrase "Water Quality Based Approach" was coined.

The development of Water Quality Criteria can approach $250,000 if all testing requirements need to be fulfilled. In an attempt to provide more information to the states, EPA began to develop Water Quality Advisories. These advisories are based on three acute values; this requires some conservatism. With only limited available information on single chemical criteria, many states began to develop effluent toxicity limits. Of the 65,000 discharge permits, over 10,000 have a toxicity limit.

In developing the validation studies of laboratory toxicity tests used in predicting ecological impact, it was necessary to develop short term chronic toxicity tests, as well as methods to conduct tests on ambient waters. We now have seven-day chronic tests and are looking at a four-day test. These shorter tests had to be developed for a Daphnia, fish and plant to provide for a more complete range of species sensitivity. The use of ambient tests has proven useful in detecting other sources of toxics. In the eight sites where laboratory and field comparison were made, only 20% of the ecosystem impact could be attributed to effluent toxicity. Ecological impacts from diffuse sources and man-induced habitat changes are often greater than those caused by toxics.

Multiple toxicity tests can be useful in obtaining an initial idea of the cause of toxicity. The difference in sensitivities of daphnias and fish to metals, organics and ammonia can be useful. Toxicity testing in the United States has greatly increased for the private laboratories. One laboratory alone conducted 8,000 tests at a cost of $1,250 each.

After a discharger discovers his effluent is toxic, one of the first questions asked is, "What is the cause of the toxicity? and/or how do I get rid of it?" A three phased approach is being developed to characterize and/or identify the chemical or chemicals causing the toxicity. The initial characterization divides the effluent into classes or types of chemicals such as heavy metals, non-polar compounds, ammonia, chlorine and soluble organics. This initial characterization is not too expensive; (about $2,000) and may be sufficient in many cases. These analyses can often be useful in designing waste treatment to remove the toxicity. The major difference with this characterization scheme is that it uses toxicity to confirm the presence of the toxicant in a particular effluent fraction.

If the toxicant is in the non-polar or water soluble fraction, the cost increases dramatically, often in excess of $50,000. This technique can be used on effluent containing multiple chemicals that contribute to the toxicity. Through the use of toxic units, the sample and sum of the fractions can be compared. There are limitations to this approach in that only acute toxicity can be tracked through the fractions and only acute toxicity tests can be conducted at this time.

Other biomonitoring techniques include the measurement of chemicals that form residues in biological tissue. The development of an analytical method that would detect only compounds that bio-concentrate by more than a fraction of 100 and exclude compounds that are not a human health threat would be helpful in the control of toxicity. Residue analysis of organisms from the receiving water has met with limited success in the U.S.

To completely control toxics, it will be necessary to know whether or not the discharge contains a carcinogen. Currently, EPA is developing a data base to determine if a small fish can be used to detect the presence of carcinogens. Presently the test takes 9 months and is fairly costly. Perhaps some day we will have an analytical tool to determine whether a chemical can alter the DNA of a cell.

States and industries are developing approaches to be used to implement the WQBA; however, most people use a rapid chronic test. Currently, over 70 laboratories can provide expertise in chronic toxicity tests. In the U.S.A. we have attempted to develop a sound scientific basis for the use of biology in the regulatory framework, and to date we have been successful in withstanding the attacks on its use.

CONCLUDING REMARKS

R.L. Thomas, Scientific Advisor
Rivers Research Branch

National Water Research Institute
Burlington, Ontario

The Workshop has provided a comprehensive overview of bioassay technology as it impacts upon or is impacted by environmental policy. Details have been well provided in the synthesis given by the summaries of the individual working groups. Here I can only give expression to a set of opinions and concerns derived largely from the Workshop presentations supplemented by some personal opinion. In large measure these serve to reinforce many of the conclusions denoted by the chairmen of the summary sessions.

My comments are not concentrated in those areas where general agreement has been achieved, but rather to flag those concerns which have been debated and remain of concern as bioassay techniques are applied toward the implementation of new environmental legislation.

Firstly, however, there appears to be a true consensus that, where effluent testing is concerned, adequate acute and chronic tests are readily available. However, it is recognized that such testing needs to be standardized and consistent protocols developed which should:

a) Be based on standard test organisms.

b) Be supplemented by the use of ambient tests organisms.

c) That batteries of tests be used in order to ensure that the "no effect level" will be discriminated at any trophic level.

It is, however, a concern that effluent testing not be taken out of context. Such tests are for the single effluent and associated process only and should be applied at the individual plant only. They must not be used to project "no effect" in a receiving ecosystem which suffers from the cumulative effect of multiple sources and must be the subject of totally different approaches.

With respect to the ambient condition, I have a number of major concerns which if overlooked or oversimplified will result in degradation of the receiving water systems. Firstly, it must be recognized that the ambient trophodynamic system is highly complex and subject to multiple natural and man induced stresses. We must recognize that the loss of any major species will change the energy flux of the system often with non–predictable results. It is clear therefore that in order to preserve the integrity of the system a test organism must represent a weak or critical link in the ambient food web. Further in order to ensure that cause effect relationships may be established then biology and chemistry must be conducted jointly after effects have been demonstrated. Again in an effort to reduce the possible permutations that may occur in establishing the biological chemical interaction full use should be made of all emerging techniques involved in QSAR and chemical fractionation.

My second major concern is an incipient failure to recognize the problems involved with the conceptualization of loadings. This concept may be summarized as follows:

1) High water volume x low concentration = high loading

2) Low water volume x high concentration = low loading

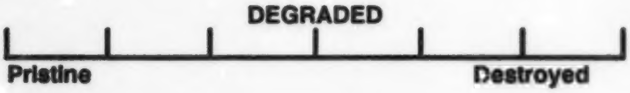
In the case of 1) above there will be no local effects on biota since the concentration is low. However, the high loading will result in the degradation of the receiving waters with long term deleterious effects on the associated biota. In the second case, real effects will be observed on biota at the concentrations in a low water volume but this in turn does not necessarily imply degradation of the receiving waters which may adequately accommodate the low loadings delivered under this scenario. Clearly a control order would be applied under scenario 2 but would not apply under 1 which represents a far worse condition for the well being of the receiving water system.

This may be well illustrated by the following table for the Niagara River.

Concentration	Loading
1 ppm	26,380 t/yr
1 ppb	26.38 t/yr
1 ppt	0.03 t/yr
1 ppq	26 gr t/yr

It has been estimated by Swain (personal communication) that for to predator fish in Lake Ontario to achieve the edible guideline of 25 ppt TCDD (Tetra chlorinated dibenzo diescin) would require an annual loading of 5 g/yr.

A further concern must be related to our definition of ambient which is normally construed to be the condition observed in the present. In the aquatic mileau we assume that the interaction of biology and water quality determines the environmental quality of that system. In this regard we must recognize an Ambient environmental quality scale as follows:



Which assumes that all systems will represent a condition ranging from pristine to destroyed in which the majority will represent some level of degradation. For any receiving system a number of questions must be addressed as follows:

1) Where does the recipient water body (environment) stand in a continuum scale appropriate for its physical, chemical and climatic characteristics?

2) Where do we want it to be?

3) 1 & 2 above determines action to be taken which ranges from no action, control of source, or full scale rehabilitation or remediation. Such rehabilitation to be targeted to the restoration of some beneficial use as, for example, according to the protocol adopted in the Remedial Action Planning (RAP) process of the International Joint Commission's designated Areas of Concern in the Great Lakes (Hartig & Thomas, 1988).

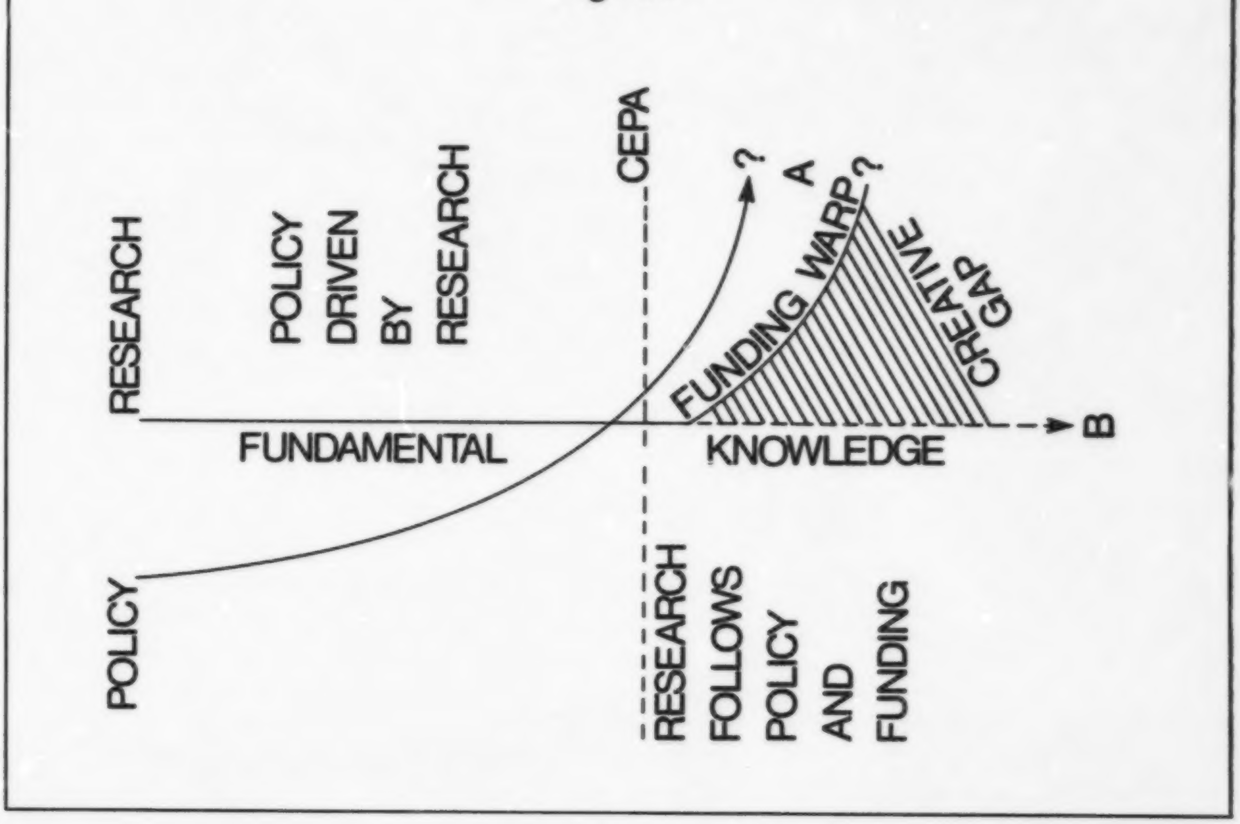
My final concern may be the most important of all since it questions as to who will be responsible for the conduct of environmental research into the future. As I review the past, it seems to me that major legislation, Agreements and Conventions reflect the current state of knowledge at the time of drafting, for example:

- The Great Lakes Water Quality Agreements 1972, 1978, Amended 1987
- The Great Lakes Fisheries Convention
- Municipal Industrial Strategies for Abatement (Ontario – MISA)
- Canadian Environmental Protection Act

This statement seems to be true to the extent that a principle can be coined to say that: "The policy today is the science of yesterday. The science of today is the policy of tomorrow." Continuing research is thus an imperative if true environmental protection and conservation is to be maintained. This is particularly important in the field of environmental bioassay which appears to be developing as a future imperative as a basis for environmental assessment and control. My concern relates specifically to the continuity of funding and the designation of responsibility in the conduct of such research.

My thoughts are summarized in Figure 1. The concept starts in the upper field where science leads policy and in which policy undergoes a continuous readjustment to the state of knowledge. Since intense policy activity will accelerate this adjustment, the policy at some stage will catch up with the scientific state of knowledge. This we see clearly in bioassay where both MISA and CEPA are state–of–the–art documents which involve the limits of current scientific ability. Since funding is currently allocated to legislation rather than to the scientific domain it is clear that only directly relevant (operational?) research will be funded. This creates what I have called the funding warp (Fig. 1) which will bring about a knowledge or rather a creative gap and lead ultimately to a complete stagnation of scientific knowledge. This is the ultimate condition of a situation where "Policy leads Science". The correction of this situation again requires a deliberate formulation of policy and a research strategy which will ensure the continuity in the development of new knowledge in environmental science. The needs of current policy in the delivery of operational science must be met by the consulting industry. This industry must be encouraged to develop rapidly and to expeditiously deploy new technologies developed in the research community. Creative research must be government funded both by allocation of grants to universities or by adequate support of in–house research capability. Government institutes must be made responsible for large scale research requiring large scale support systems, e.g., biological effects in oceans, large lakes and rivers and over large regions whereas university research should accept the responsibility for the smaller scale high resolution research needed for the insights into understanding and controlling of processes down to the molecular level. It is clear that cooperation and collaboration between the three science sectors is essential if Canada is to excel in environmental research. It is equally clear that the whole field of bio–assessment at the laboratory, effluent and ambient levels serves as an ideal basis for the implementation of such a research strategy.

Figure 1


RESEARCH
POLICY DRIVEN BY RESEARCH
CEPA
?
A
?
FUNDING WARP
CREATIVE GAP
FUNDAMENTAL
KNOWLEDGE
B
POLICY
RESEARCH FOLLOWS POLICY AND FUNDING

APPENDIX C

Rapporteur Reports of Working Groups

WORKING GROUP #1

CHAIRPERSON: P. Blackall
RAPPORTEUR: H.R. Eisenhauer

Apart from the Chairperson and the Rapporteur, the Working Group consisted of representatives from the federal government (4), provincial government (3), industry (4) and consultants (3). There were no representatives from the university sector or public interest groups.

The working group members represented a broad range of managerial responsibilities accounting for a rather disperse list of identified needs. Input by all participants, especially from industry and consultants was strong and positive.

Strategy

Considerable time was spent debating the approach which should be taken in addressing the four identified issues. It was finally agreed that the working group would

- limit discussion to regulation on the basis of biological effects assessment
- identify generally broader "generic needs" in addressing the first question
- generally consider the needs over a five-year time horizon

Question #1

Need 1. It was felt that standards should not be set simply on the basis of best available technology (BAT) of the moment, and adjusted as the BAT is improved over time. There should be some assurance that such regulations or standards will remain unaltered for a reasonable period of time.

Need 2. In-plant biological monitoring systems with sufficiently rapid responses should be developed so that corrective measures can be taken in the event of a plant upset.

Need 3. identifies the requirement for the development of new biological tests to meet specific basic principles or criteria before they are adopted by regulatory agencies and the industry. This will ensure their validity and usefulness.

Strong QA/QC programs are essential to validate the results of laboratories in the private and public sectors. Such programs identified in Need 4. should result in laboratory certification to identify those which have demonstrated reliability and reproducibility. This would increase the credibility of the results of testing and assure the public that there is no collusion between government and industry.

The working group expressed the view that regulators should not impose mandated tests on industry before the necessary analytical infrastructure was in place to undertake the tests. Need 5. therefore expresses the requirement for sufficient advance warning to ensure that new tests can be accommodated prior to promulgation of regulations. It was suggested that this could be achieved by government using the strategy of "technology forcing regulations" in which a regulation is issued with a schedule for compliance which recognizes setting in place the necessary analytical services.

A hazard assessment scheme (Need 6) is required which takes into account all environmental impacts resulting from a pollution abatement decision. For example, is it more effective from the point of view of environmental impact, to cut down on cooling water use by converting to fan-driven air cooling when the latter requires the production of additional power from a hydro plant through the diversion of more water through its turbines.

Need 7. relates to ensuring an adequate degree of public consultation and participation in matters relating to biological testing or monitoring. Concern was expressed, however, that neither government nor industry are trusted by the public, and we are therefore obliged to use credible third parties to pass on relevant information to the public while we work hard to regain their confidence.

Industry is concerned that different jurisdictions demand different biological testing methods or procedures for regulation. Need 8. recognizes the wish that protocols be standardized or harmonized as far as possible regionally, nationally and internationally. Several members suggested that Canada should simply adopt OECD or EPA protocols. Others pointed out that uniformity is not possible in Canada given the diversity of its water resources, and that the adoption of such a strategy would stifle Canadian R&D on the subject.

A flexible regulator framework (Need 9) is essential to permit the replacement of existing biological tests by newer, more efficient and less expensive testing procedures. The kind of test which will provide the information needed to demonstrate compliance should be subject to negotiation between the regulator and the industry.

Need 10. expresses the requirement for improved means of educating the public to the significance and purpose of biological testing and its results.

A majority of the working group felt that the certification of toxicologists in Canada (Need 11) would be an advantage.

Question No. 2

Government has a role to undertake long term research, and the resources and expertise to mount significant multidisciplinary research programs related to biological pathways, fate and effects in the environment. It should encourage universities to cooperate in such ventures.

Neither government nor university laboratories should enter into competition with the environmental service sector by providing biological monitoring or testing services to industry. Government's role in this area should be providing QA/QC assistance and supplying its own needs.

All members agreed that governments should be involved in the transfer of technology to the private sector, which in turn, should have the opportunity to exploit such technology.

Although the Working Group did not address the funding of R&D directly, the implied position was that governments should fund whatever R&D they did internally or by contract in the private or university sectors. A cautionary note was added that expertise, and R&D activity within government laboratories must be maintained at levels sufficiently high to manage R&D contracts effectively and to maintain viable in-house programs.

Question No. 3

The Working Group agreed that governments should have a QA/QC role and that there be self-assessment by industry with auditing by government(s). This demands the certification of service sector labs as discussed previously.

Question No. 4

Responsibility for ambient bio-effects assessment depends on the location within the system where monitoring should be conducted as follows:

(a) Regional ambient monitoring – government(s).

(b) End of pipe monitoring – industry with government audit.

(c) Multiple Effluent Zone (e.g., St. Clair River) – shared responsibility where site specific conditions dictate the relative proportion between industry and government.

WORKING GROUP #2

CHAIRPERSON: R. Baker
RAPPORTEUR: P. Stokes

Question No. 1

There was some consideration given to the "bounds" of the discussion. It was agreed that our objective was to look at needs, in the context of regulation and not in terms of generating information. To paraphrase one of the groups, "the government has to make the decisions (on regulation) and the industry has to live with the decisions". It was also pointed out at this time that a decision not to regulate was still a regulatory decision. There was some concern as to the product of the workshop, and it was suggested that a collective statement or recommendation from the gathering would be useful. We have therefore outlined a number of generic needs and attempted to identify the respective benefits and disadvantages of each perceived need. Following the summary of the generic needs, some specific comments on some of the available methods or approaches to biological testing are provided.

The generic needs are outlined below. There has been no attempt to rank or imply preference of order in this list, but rather to logically group various sets and to assist in consolidating some of the concepts.

1. Standardize protocols. There was absolutely no disagreement that in principle and in fact, protocols should be standardized. This should be at least on a jurisdictional basis, and some protocols can be developed and used at a national level. The advantages are obvious, and there seem to be no disadvantages beyond cost. (Although see 4. Flexibility). The initial cost of doing this as well as the ongoing cost of checking protocols has to be accepted as a need.

2. Have consistency in tests. This means more than providing protocols. There should be consistency within a test as well as consistency as to the type of test. Among industrial sectors or process areas, there would almost certainly be differences in terms of the types of tests, but greater national consistency is needed for tests within industrial sectors. The advantages have to do with fairness, as well as the scientific need to be able to make comparisons (between apples and apples rather than apples and oranges). The disadvantages include the potential for excessive rigidity, and this is addressed in 4.

3. Define existing conditions and "keep it simple". Before embarking upon a series of elaborate and sophisticated tests, the current stage (of the water or waste) should be addressed, and the appropriate test used. The example given was for effluents that had low LC50's in acute toxicity tests. If the effluents are still acutely toxic, as many are in certain sectors, then simple acute toxicity tests are all that is required under the existing condition. This approach seems manageable, reasonable and logical, and could save a great deal of time and money; in other words the benefits are more efficient use of resources and regulation efforts. It was referred to in Westlake and Ralston's plenary paper. There could be a disadvantage if over time the acute tests are the only ones used, because some more subtle effects could be missed.

4. Allow flexibility. From past experience, and the general feeling that every instance should ideally be considered on a site- or case-specific basis, flexibility, without losing sight of No. 1 and 2, was advocated. The issue of flexibility can be addressed at the strategic level, e.g., a national strategy for pulp mill monitoring with a core program common to all and with optional elements that would be used only when a specific situation required it. Again this provides an element of fairness, allows for the application of existing information, and can also leave some discretion to the industry or other proponent. Taken to excess, there could be problems with departures from interpretable test procedures, but with No. 1 and 2 in place, there would be little danger of this. No incompatibility between 1 and 2 respectively and 4 was perceived. As one member put it, "The goalposts are defined, but one can use different parts of the field (sides or middle), as long as one proceeds towards the goal."

5. Use a practical approach. This is not the same need as 3, keeping it simple, (although the effect might be the same). The tests, in terms of protocols and requirements, should be "do-able" in the conditions under which the industry operates. This means recognizing that in remote, or isolated, or unsophisticated set-ups (e.g., far-north), the tests should be suitable for those conditions, or if the sample has to be transported long distances, the test should

require small volumes of sample. In addition, if the sample has to be sent out, due regard should be given to the condition of the sample during and after transportation.

6. Use the receiving water as diluent. In many instances, it has been shown that the result of a toxicity test carried out with the natural receiving water as diluent is a lower index of toxicity than that obtained with lab medium or lab water. Occasionally the converse happens, suggesting that the receiving water is already burdened with some toxicant or promoter of toxicity, which could be natural, or a product of some other process which releases effluent into the water. The benefit of this is realism. The disadvantage to the proponent, if the water is already polluted from upstream, is that he/she is punished (?unfairly) for someone else's contamination.

7. Take a tiered approach. A strategic or staged approach was favoured, with e.g. tests close to a point source before tests in the mixing zone, and acute tests before chronic, etc. To a degree, this is the same philosophy as 3. Like 3, it provides for the most effective use of funds and other resources, but the selection of the tests at each tier requires a great deal of skill. There are dangers with the tiered approach, e.g., fish may live in the effluent, but show reproductive impairment over the longer term. The tiered approach is in fact already in use to an extent, and was referred to by a number of speakers in the plenary sessions.

8. Do not lose sight of sublethal tests. Logically following from the possible disadvantages in 3 and 7, there is a need to always remember the importance of sublethal effects. The advantages have been dealt with in terms of the disadvantages related to restricting tests to determination of acute lethality.

9. Look at the ratio acute:sublethal. It is possible to determine if there is a relationship between these types of tests that can be used to simplify the procedures. This again will contribute to cost efficiency, and, if the relationship is reliable, this will add some support to the simplification philosophy.

10. Look for surrogate tests. With appropriate justification such as correlation analysis, certain tests can be replaced by surrogates. The example given was the use of the bio-oxidizer as a surrogate for a toxicity test. While this particular example was not favoured (the bio-oxidizer was seen as a way to manage the effluent, and was not in one person's opinion suitable as a regulatory tool), in principle, surrogate tests were supportable. As an adjunct, comparative biotests were cited, in which e.g., an algal test agreed very well with a fish test, and could be used as a surrogate, with a saving in time and money. It has to be stressed that there is a potential disadvantage if the relationship is not a strong one.

11. Consider a battery of tests. This was used in a specific way, meaning a "package" of tests prescribed to cover human health and environmental concerns at the same time. (Health and Welfare Canada were involved with writing the new CEPA and there should be some joint efforts.) There was some suggestion that the way in which radionuclides and pesticides, respectively, are regulated, might provide some useful model to link human health and environmental quality considerations.

12. Apply an integrated ecotoxicological approach. Standardized simultaneous integrated testing for several trophic levels (as well as possible interactions?) was advocated by some. This is a contrasting point of view to the tiered testing or the "keep it simple" philosophy, although to some extent, the degree of disagreement depends upon the stage at which the ecotoxicological tests are done, i.e., whether or not some initial screening by simple tests is acceptable prior to the ecotoxicological approach.

13. Tests should be cost–effective. The need to be cost-effective, to use resources (those of government, industry, in fact of all stakeholders) effectively and responsibly, is reflected in most of the needs listed above. But consideration of costs should not dominate consideration of scientific needs.

14. Control of procedures, and accreditation of labs. Labs should be accredited; quality assurance and quality control are essential. (see Q.3). Not only is this scientifically defensible, there is also a value in the perception of a QA/QC programme. The budgets of certain large programmes in the US EPA for example, have a high allocation to QA/QC.

15. Communicate the meaning of regs. to the public. Some form of education or explanation needs to be provided to assist the public in comprehending regulations, and in feeling that there are some reasonable attempts being made to protect the environment. The public is unlikely to have problems understanding a trout toxicity test, but other tests, e.g., microtox, are conceptually more difficult. Some form of communication (fact sheets?, public meetings?, workshops?) will aid in the understanding and acceptance of these tests.

There was also some discussion about education of the judiciary in terms of toxicity testing, but this was felt to be unnecessary: if the regulation is laid down, then the judge has only to determine whether the regulation was violated or not. It is not necessary for him/her to understand the test. Nevertheless, an instance was cited where a judge discounted evidence based on a rainbow trout test, on the basis that the species did not occur in the area. In cases where a non–routine test is brought in as evidence, there may be a need on a case–specific basis to communicate the principles of testing to the judge.

16. The government should set clear precise regulations. The setting of regulations is not the job of the people, but of government with the appropriate expert advice. The public tells the regulator what environmental quality ob-

jectives it wants to have maintained or restored, and then it is up to the experts to decide how to best achieve the objectives. Monitoring would have to part of this strategy (see 18).

17. Get the regulations out fast. There already are a few biological tests, especially for effluent discharges, that are well proven and in active use in some jurisdictions. It was proposed that some of these should be put into regulations as fast as possible, rather than waiting for another five years and spending more money on confirming the usefulness of tests that are already well tried. Others could be added, as well as refinements made, later on. R&D efforts (see 2) should be concentrated on promising tests that are not yet proven, and assessment made on a continuing basis of the quality of the environment (see 4), so that the effectiveness of the "in place" tests can be determined. The results of the R&D, if it produced better tests, could be added to regulations later on. But it is imperative to get started with something almost immediately. Residual toxicity might also have to be defined later.

In the subsequent plenary discussion, it was pointed out that once a regulation is "in", it is very difficult to change it. Skillful wording and options for flexibility might obviate some of this concern.

18. Licencing permits should be open to public participation. A point which was raised by one of the plenary speakers on the previous day, was the concept of letting the public decide, on the basis of its needs and goals for land use, what environmental standards (and therefore regulation) would be appropriate for a particular area. The advantage of this is in part political, but it also brings a pragmatic component into the decision–making process. There was some concern that this principle could produce "pollution havens". It is also necessary to consider subsequent changes in land use (e.g., old industrial sites, and other inner city areas are currently becoming modified for residential use. Contaminated sediments in such regions could pose a health risk).

19. Use risk assessment to provide criteria. The ultimate decision on judging a test result, or setting an acceptable level, has to be based on risk assessment. The determination of risk is scientific, but the acceptance of risk and risk–benefit considerations are in the public domain, and are essentially political.

20. Need for a basic understanding of impacts on rec. waters. Before dealing with a specific test or defining a regulation, it is necessary to have an understanding about the action of the contaminant on the receiving water. This requires basic research, and may lead to the need to include different trophic levels in the tests. In a particular regulatory regime, some residual impacts can be identified and existing regulations altered to deal with them. In some cases, however, residual impacts are not known or predicted. Monitoring and research initiatives should be flexible and creative enough to pick up on these, pose impact hypotheses and rigorously test them.

21. Consider the use of indigenous species. As an alternative to, or perhaps more realistically, as an adjunct to, testing with "standard" organisms, it was suggested that, especially in instances where the prescribed test organisms did not occur in the region or water body of concern, that some tests should be done on indigenous species.

22. Use toxicity tests in the development of technology. One very significant area of application of toxicity testing is in the technical development of systems to reduce toxicity.

Specific comments on ambient water testing

There was considerable discussion about the meaning of ambient testing. It is used here to mean the laboratory testing of any water sample from the ambient environment, and could range from the middle of Lake Ontario to the edge of the mixing zone of an effluent. If ambient testing is done in the mixing zone, it can and is being used to identify specific polluters as well as to determine the effectiveness of existing controls. On the other hand, if it is done in the middle of the lake, it is less specific, but still has a role in assessing environmental quality. In this context, the analogy was made that ambient testing "finds the body", but in order to solve the murder, it is necessary to "find the knife" and then "identify the murderer who used the knife". It is extremely important to monitor the quality of ambient water. If a problem in ambient water quality is detected in the "open water", then one must work backwards to identify the source. (The control of phosphorus in response to eutrophication was a good example of this type of regulation, but possibly a simpler one to handle than a mixture of toxicants.)

In theory, if all sources (proponents) are regulated, and if all are in compliance there should be no problem with ambient water quality, but this assumes "ideal" regulation and total compliance. In fact, neither of these can be achieved, and furthermore, a mixture of individually innocuous residues may prove to be toxic in combination. Therefore we felt that it was essential to test the quality of ambient water. Ambient tests can identify a problem, but sources still have to be identified.

There was a great deal of discussion about the "mixing zone", which is clearly a significant concept in regulation of water quality. Canada and the USA have different opinions concerning the use of the mixing zone concept in regulation.

The following recommendations and needs specifically for ambient testing were identified.

1. Tests for ambient water quality should be tied to water quality objectives. At present there are some water qual-

ity objectives, e.g., for the Great Lakes, but these are chemical. We need biological criteria or objectives. Contrary to general expectations, objectives can be used and have been used (the example was Ontario) to bring about legal action on water pollution.

2. For ambient tests, use sublethal or chronic tests.

3. It is necessary to define the regulatory mechanism(s) for ambient water.

4. Distinction should be made between wastewater and ambient types of testing (although the tests per se may not differ between the two). Normally, it would not be necessary to do both ambient and wastewater testing.

5. It was pointed out that in certain situations, e.g., an (accidental) spill, the ambient test was essential. It could be used to delineate the extent of the effect, as well as to determine the type of effect. It could lead to prosecution.

Specific comments on in situ tests

In situ tests, such as the use of indigenous fish or algae, or caged organisms placed in the natural environment, or reciprocal transplants from "clean" to "dirty" areas, were favoured for a number of reasons. The current situation however does not provide for many such tests in the regulatory framework, and the group would like to see this area widely accepted, and specific regulations in place. In summary, the group made the following points.

1. In situ tests, in theory at least, can integrate exposure, while chemical tests normally represent one point in time. A chemical sample may "miss" a significant pollution event, or alternatively may over-emphasize a specific episode. The in situ organism is normally one that is a natural resident of the ecosystem. (The selection of the actual organisms, whether it should be a "keystone" member of the system or a relatively unimportant one, is a major point for discussion which was omitted in the interest of time.)

2. In situ tests can conveniently be combined with residue measurements (see below).

3. There is a need to standardize in situ tests with respect to the organisms and the criteria.

Comments on residue measurements/tests

Residue measurements involve whole animal or plants, or specific types of tissue, which are collected and in which the concentration or the body burden of the contaminant is measured. It is important to recognize the limitations to this method, or rather the potential for misinterpretation of the data. One major area which should be of concern is the fact that accumulation tends to change with age and/or size of an animal. There are also very significant inter-specific differences, even for closely-related organisms, and for those in the same feeding guilds, so all of these potential problems have to be borne in mind and built into protocols. The group made the following observations and recommendations.

1. For food items, the residue concentration has a direct implication for human health effects.

2. For food items, standards or criteria already exist for major contaminants.

3. The use of tissue analysis improves the detection limit, since most contaminants accumulate in tissue, with a concentration factor (CF) greater than unity. Many substances that are close to the instrumental detection limit in water can be easily measured in tissue.

4. Tissue residues can identify priority pollutants and can also give "early warnings" of pollutants in aquatic systems.

5. The group was unsure how to regulate but there was a recommendation that regulation should consider food chain effects, e.g., small fish such as spot-tailed shiners which provide food for higher predators, could have tissue residues regulated and this would serve as a standard to protect the higher trophic levels.

Question No. 2

Several areas for research were defined in the course of the "needs" discussion, as well as during the time allotted for this question. Some of the more pressing were identified as follows. We tried to consider those areas which we "need to know", and not simply those which it would be "nice to know".

1. There is a need for greater understanding of the impacts of toxic substances on receiving waters.

2. The question of sub-acute or sublethal to acute ratios, described above was raised here as requiring research.

3. Biotests should be causally-related.

4. There should be a closer link between biotechnology and ecotoxicology.

There was complete agreement that in the area of regulation, i.e., the government should be responsible for research programs. However, specific work could be assigned to those with the capability, and this could be scientists from government, industry, private consulting or universities.

There was also general agreement that the government would not necessarily bear the entire financial responsibility. In the case of development of a specific product, for example, the company would clearly pay, but most R&D labs in industry are not geared to develop scientific tests. There was some discussion of the merit of using polluter fines to pay for research. This is already done in some European countries, as well as in some states in the USA. At present no decision has been made concerning MISA fines, but apparently the fines are destined to go into one large "pot". While there is some logic to having the polluter pay for the research, there is the danger that insistence *on direction of this revenue to research* might expose the fact that at present, revenues from other sectors provide research funds. There is also the possibility of the "quote system" mentality prevailing if these fines are designated to a specific research use.

As stated above, the decision on who does the actual R&D work should be based on competence. The concept of Centres of Excellence is most appropriate for carrying out this type of R&D.

Question No. 3

1. All labs carrying out testing should be accredited.

2. Self–assessment should be the rule, with industry doing routine testing, and the government taking the occasional audit.

3. This requires very specific protocols, which the government should provide and be responsible for maintaining.

4. The government should provide a manual of good laboratory practices.

5. Protocols and lab practices must be enforced by government.

Question No. 4

It is the government's role to assess or evaluate the effectiveness of existing regulations in the receiving environment. It also is the government's responsibility to identify emerging or unpredicted problems that need to be addressed by regulatory regimes. Furthermore, government has the responsibility to develop new tests and the frameworks in which they should be applied. Although the ultimate responsibility for assessment should be with the government, the work can be delegated. Not only was there agreement that assessment was part of ongoing regulation, there was also some consideration in the group for those substances that are no longer "used", i.e., cannot be purchased, but which are still present in the environment.

A number of people spoke in favour of the value of long–term datasets, and considered that the maintenance of monitoring schemes was the responsibility of the government. However, the data should be used and be seen to be used.

There is a natural reluctance to continue collecting data for its own sake, yet discontinuing such collection has resulted in several missed opportunities. The only type of assessment that should be left as the primary responsibility of the industry is the assessment of the immediate area of impact around its operation.

There was a "plea" for the establishment of ecological reserves or observatories, at least five for Canada, which (like Hubbard Brook) could be used for long term observation of "natural" systems, determination of climatic change, of long range transported pollutants, etc., as well as for experiments.

One major area of ambient assessment by government should be evaluation of the effectiveness of regulations, both on a local and longer range scale.

WORKING GROUP #3

CHAIRPERSON: K. Marshall
RAPPORTEUR: D. Carlisle

The composition of the group consisted of representatives from all sectors – provincial and federal government, industry, universities and consultants, as well as Dr. Nelson Thomas, U.S. EPA.

Question No. 1

In its attempts to answer question no. 1, the group developed some general principles as follows:

1. Clarify nomenclature and definitions to ensure, for instance, that such words as "chronic" are given the same meaning in both medical and environmental toxicology. This is not true at present.

2. Standardize testing protocols – but

3. Allow for flexibility by using Guidelines, rather than Regulations, as the instruments of regulation, all within a consistent regulatory framework.

4. If any test is prescribed by the government then the precise objectives of that test should be described in detail, so that operators are clear about what they are supposed to do and why.

5. Government must make a clear statement of policy, both in the legal aspects and in the implementation of biotesting.

6. Biotesting should lead to solutions of problems. Since plant operators must put these solutions into practice by means of modifications in process engineering, then, the results of tests should be expressed as nearly as possible in terms which lead directly to process engineering.

7. An ideal protocol should consist of tiers of tests, with each tier provided with quantified triggers, leading to the next tier, if and only if, the trigger is tripped. This is expressed in the acronym TTT – Tier Testing with Triggers.

8. Long–term tests must be related to short–term tests, and R&D must be undertaken with the aim of using shorter, cheaper tests as surrogates for the longer more expensive tests. The ultimate desideratum is the development of microbiological tests which can be automated, or of biosensors which can be placed into process control systems.

9. All problems should be subjected to some form of "Relevance Evaluation" so that attention (and money) can be concentrated on the more relevant problems.

10. Ensure public comprehension of all programs and communicate an evaluation of all risks to the public.

Finally, the group developed a generalized procedure which might be applied to develop a monitoring/testing scheme for any specific project. This procedure demands a prior knowledge of base-line data and hence a national environmental quality monitoring program, and moves through biomonitoring to biotesting, chemical monitoring, and to process engineering and ongoing controls, with public information and participation. The generalized scheme can be summarized as follows:

1. Is there environmental change from base-line data? If so, then
2. Does the change constitute a problem? If so, then
3. What is the source of the change?
4. What are control strategy options?
5. How are the controls to be implemented?
6. How can we conduct ongoing audit of controls?
7. How is the public best informed of the problem and possible solutions and what role can the public play?

Question No. 2

The group developed four general principles:

1. Government MUST maintain at least one centre of expertise for in-house research in biological testing and monitoring, otherwise it will lose all credibility and all capability of auditing contract work or work by the private sector.

2. Government has the lead role and sets the objectives for environmental quality. This is only possible if condition #1 is met.

3. Government may need to assign accountability for discharges and may need to pay for research for this to be done (Liability Analysis?). Industry only pays for research when it has been shown to be accountable.

4. There is no real role for "partnership" in R&D between government and the private sector. Neither side would welcome it and ownership of proprietary information would become murky. Government and business work better apart.

Industry was considered to have three main roles in R&D for biotesting:

1. Companies pay directly for R&D on pertinent discharges and releases.

2. Industry pays for research into toxicity of specific substances developed for commerce.

3. Industry must pay more heed to Technology Transfer, which should not be a one-way street.

The group considered the role of government under five main heads with respect to R&D:

1. The government is responsible to the public for reporting on the state of the environment and must carry R&D to fulfill this assignment.

2. Government is responsible for the protection of the public interest and of shared resources.

3. The government must define the level of protection needed in any specific case.

4. Most fundamental research in biotesting should be carried out by the government, both through direct labour and through universities, funded by government. Government laboratories must carry out fundamental research, both to maintain the necessary expertise and to keep up with "state of the art", and to be qualified for the necessary audit role of industry biotesting. The value of university research has been emphasized by the recent independent analysis of the old IWD university research subvention program, and this should be reinstated, with better funding than before.

5. Government should place more emphasis on multichannel technology transfer.

Question No. 3

The group felt that QA/QC played a key role and that any testing or monitoring program was only as good as its QA/QC. Accordingly, the following four principles were enunciated:

1. Government has the lead role in all QA/QC and the public will hold government accountable for any lack.

2. Government must audit all QA/QC components of all programs, governmental or industrial and impose an additional tier of QA/QC.

3. Every testing program must include QA/QC, paid for by the "owner" of the program. The additional tier of QA/QC needed for audit should be paid for by government.

4. National accreditation schemes are needed for all laboratories (chemical and biological) and for individual toxicologists. Biologists and chemists should collaborate in establishing such schemes.

Question No. 4

The group gave short shrift to question no. 4, feeling that the government is responsible for ambient assessment and pays for it. If, however, a problem has been identified and a company found responsible for that problem, then industry pays for ambient assessment (but the government audits what industry is doing). Government always remains responsible for far-field monitoring.

WORKING GROUP #4

CHAIRPERSON: K.R. Solomon
RAPPORTEUR: K.E. Day

Question No. 1

There was a number of generic points that came out of the discussion as follows:

1. One should not try to separate the laboratory from the field, i.e., there is a clear need for both laboratory and field biological toxicity tests to be used in conjunction with chemistry for regulatory purposes.

2. Toxicity tests should be built on a "tiered approach" with short term, acute lethality screening tests first followed by long-term, chronic sublethal tests which are more definitive for determining effects on ecosystems.

3. There is a need for clear and definitive protocols for biological toxicity tests.

4. Environmental conditions create site-specificity and must be taken into consideration in the development of toxicity tests, i.e., temperature, pH, O2, etc., are factors 'on-site' that create variability.

5. Laboratory toxicity tests are important

for initial screening of effluents and fine-tuning of treatment processes but more sensitive tests need to be developed.

6. Regulatory end-points (sublethal) are unclear for ecosystem protection at this time and require development.

7. Field validation of toxicity tests is essential in order for tests to be functional.

8. There is a need for a better understanding of the effects of mixtures especially in a regulatory sense.

Question No. 2

There was general agreement that government should take a leadership role in R&D with private industry conducting complementary research. It was recommended that increases in funding allocation for staff and resources within government is necessary.

There is a need for transfer of technology to the private consulting sector.

Government should not be conducting routine in-house testing for industry or the private sector but should have a lead role in

1. auditing
2. maintaining a legal function
3. internal in-house capabilities in order to maintain QA/QC

Question No. 3

There is a clear need for QA/QC and the certification of laboratories. Government must play a strong role in QA/QC and there should be cooperation between laboratories and the regulators.

Question No. 4

There are two types of assessment:

1. Site-specific assessment which is better conducted by industry. They have the ability and probably the desire to monitor on-site but there is some question of public accessibility to data.

2. Watch-dog assessment which is better conducted by government for the following reasons:

a. long-term monitoring on a continual basis is government's responsibility

b. covers large areas not within confines of industry

c. state-of-the-environment reporting which is the government's responsibility

APPENDIX D

List of Participants

Mr. B. Baker, Senior Biologist, EP/C&P/Environment Canada, Hull, Quebec

M.N. Bermingham, EP/C&P/Environment Canada, Longueuil, Quebec

Mr. D. Birkholz, Enviro–Test Laboratories, Edmonton, Alberta

Mr. D. Bisset, Environmental Affairs, Shell Canada Ltd., Calgary, Alberta

Mr. P. Blackall, EP/C&P/Environment Canada, Edmonton, Alberta

Dr. C. Blaise, EP/C&P/Environment Canada, Longueuil, Quebec

Dr. G. Blouin, Department of Environment, St. John's, Newfoundland

Ms. E. Bottomley, EP/C&P/Environment Canada, Hull, Quebec

Mr. J. Cairns, Dearborn Chemical Co., Mississauga, Ontario

Dr. D. Carlisle, IWD/C&P/Environment Canada, Hull Quebec

Mr. P. Chapman, E.V.S. Consultants, North Vancouver, B.C.

Dr. B. Chen, DOW Chemical Canada, Inc., Sarnia, Ontario

Dr. L. Churchland, IWD/C&P/Environment Canada, West Vancouver, B.C.

Dr. M. Clark, B.C. Ministry of Environment & Parks, Victoria, B.C.

M.M. Couillard, Montreal, Quebec

Mr. G. Craig, BEAK Consultants Ltd., Mississauga, Ontario

Dr. K.E. Day, C&P/NWRI/Environment Canada, Burlington, Ontario

Mr. B.J. Dutka, C&P/NWRI/Environment Canada, Burlington, Ontario

Dr. W.R. Effer, Ontario Hydro, Toronto, Ontario

Dr. H. Eisenhauer, EP/C&P/Environment Canada, Hull, Quebec

Mr. M. Frost, Canadian Pulp & Paper Assoc., Montreal, Quebec

Mr. E. Hanna, J.E. Hanna & Assoc., Pickering, Ontario

Ms. J. Harker, M&M Dillon Ltd., Willowdale, Ontario

Mr. Tibor Haasz, Municipality of Metropolitant Toronto, Toronto, Ontario

Dr. P. Hodson, Department of Fisheries and Oceans, CCIW, Burlington, Ontario

Dr. S. Hrudy, University of Alberta, Edmonton, Alberta

Mr. C. Innis, Ontario Ministry of the Environment, Toronto, Ontario

Dr. B. Jank, Wastewater Technology Centre, CCIW, Burlington, Ontario

Dr. A. Jones, May & Baker, Mississauga, Ontario

M. G. Joubert, Ste. Foy, Quebec

Dr. T. Kenichinton, P.A. Lane & Assoc. Ltd., Halifax, N.S.

Dr. N. Khan, Department of Fisheries and Oceans, Ottawa, Ontario

Mr. T. Kierstead, Petrosar Ltd., Sarnia, Ontario

Mr. T. Kovacs, Pulp & Paper Research Institute, Pointe–Claire, Quebec

Mr. R. Kwiatkowski, IWD/C&P/Environment Canada, Hull, Quebec

Ms. J. Legault, C&P/ NWRI / Environment Canada, Burlington, Ontario

Dr. J. Lawrence, IWD/C&P/Environment Canada, Burlington, Ontario

Dr. H. Lerer, Commercial Chemicals Branch, C&P/Environment Canada, Hull, Quebec

Mr. I. MacDonald, EP/C&P/Environment Canada, Ottawa, Ontario

Dr. M. MacKinnon, Syncrude Canada, Ltd., Edmonton, Alberta

Ms. P. MacQuarrie, C&P/Environment Canada, Hull, Quebec

Mr. K. Marshall, CWS/C&P/Environment Canada, Hull, Quebec

Dr. C. Mayfield, University of Waterloo, Waterloo, Ontario

Ms. L. McArthur, Ottawa, Ontario

Dr. E. D. Ongley, C&P / NWRI / Environment Canada, Burlington, Ontario

Dr. D. O'Shaughnessy, Chipman Inc., Stoney Creek, Ontario

M. R. Prairie, Noranda Research Centre, Pointe-Claire, Quebec

Mr. J. Ralston, Ontario Ministry of the Environment, Toronto, Ontario

Dr. S. Ramamoorthy, Alberta Department of the Environment, Edmonton, Alberta

Dr. T. Reynoldson, C&P/NWRI/Environment Canada, Burlington, Ontario

Dr. D. Rodgers, Ontario Hydro, Toronto, Ontario

Mr. B. Ruggles, Saskatchewan Environment and Public Safety, Regina, Saskatchewan

Dr. H. Sadar, Environment Canada, Ottawa, Ontario

Dr. M. Samoiloff, Bioquest International Inc., Winnipeg, Manitoba

Ms. L. Sarazin, EP/C&P/Environment Canada, Toronto, Ontario

Mr. W. Scheider, Ontario Ministry of the Environment, Toronto, Ontario

Dr. B. Schiefer, University of Saskatchewan, Saskatoon, Saskatchewan

Mr. C. Schenk, Ontario Ministry of the Environment, Toronto, Ontario

Dr. K. Schiefer, BEAK Consultants Ltd., Mississauga, Ontario

Mr. A. Schuldt, Stelco Inc., Hamilton, Ontario

Mr. R. P. Scroggins, Industrial Programs Branch/C&P/Environment Canada, Hull, Quebec

Mr. G. Sergy, EP/C&P/Environment Canada, Edmonton, Alberta

Dr. K. Solomon, Canadian Centre for Toxicology, Guelph, Ontario

Mr. M. Speyer, Noranda Research Centre, Pointe-Claire, Quebec

Dr. P. Stokes, Institute for Environmental Studies, University of Toronto, Toronto, Ontario

Mr. M. Sudbury, Falconbridge Limited, Toronto, Ontario

Ms. M. Taylor, EP/C&P/Environment Canada, Hull, Quebec

Dr. R. L. Thomas, C&P/ NWRI / Environment Canada, Burlington, Ontario

Dr. T. Walker, National Research Council, London, Ontario

Dr. W. Warwick, C&P/NHRI/Environment Canada, Saskatoon, Saskatchewan

Dr. P. Wells, EP/C&P/Environment Canada, Dartmouth, N.S.

Dr. G. Westlake, Ontario Ministry of the Environment, Rexdale, Ontario

Dr. B. Wilson, C&P/Environment Canada, Hull, Quebec

Dr. C. Wren, B.A.R. Environmental, Guelph, Ontario

Mr. P. Wiancko, Ontario Hydro, Toronto, Ontario

Mr. A. Yee, Canada Packers Inc., Toronto, Ontario

APPENDIX E

Organizing Committee

Dr. D. Carlisle, IWD / C&P / Environment Canada
Hull, Quebec

Dr. K. E. Day, C&P / NWRI / Environment Canada
Burlington, Ontario

Dr. H. Eisenhauer, EP / C&P / Environment Canada
Hull, Quebec

Ms. J. Legault, C&P / NWRI / Environment Canada
Burlington, Ontario

Dr. E. D. Ongley, C&P / NWRI / Environment Canada
Burlington, Ontario

Mr. R.P. Scroggins, C&P / IPB / Environment Canada
Hull, Quebec

Dr. R. L. Thomas, C&P / NWRI / Environment Canada
Burlington, Ontario